DOCUMENT RESUME

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INSTITUTION Oklahoma State Board of Vocational and Technical Education, Stillwater. Curriculum and Instructional Materials Center.

PUB DATE 82

NOTE 121p.; For related teacher's guide and packets, see ED 236 346 and CE 046 464-465.

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ABSTRACT

This learning activity packet (LAP) outlines the study activities and performance tasks covered in a related curriculum guide on milling machines. The course of study in this LAP is intended to help students learn to identify parts and attachments of vertical and horizontal milling machines, identify work-holding devices, state safety rules, and perform general maintenance. The tasks presented in the LAP are designed to help students gain a moderately skilled or skilled competency level with respect to cleaning and lubricating horizontal and vertical mills. Included in the LAP are unit and specific objectives, a pretest, information and assignment sheets, cross-references to the curriculum guide, job sheets, and answers to the pretest and the assignment sheets. Page numbers in the LAP are coordinated with those in the curriculum guide. (MN)

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State Department of Vocational and Technical Education CIMC Stillwater, Oklahoma LEARNING ACTIVITY PACKETS

for MILLING MACHINES

LAP NO. _____ CODE: _____

INSTRUCTIONAL UNIT UNIT I--INTRODUCTION TO MILLING MACHINES

LEARNING ACTIVITY PACKET NO. 1

PREREQUISITE LAP(S) None

PURPOSE: This Learning Activity Packet (LAP) outlines the study activities and performance tasks for "Introduction to Milling Machines." Accomplishing these procedures will aid the student in attaining a working knowledge of this area of training and in achieving a Skilled or Moderately Skilled competency level in the performance of jobs associated with this specialty.

INTRODUCTION: The course of study in this LAP will help the student become able to identify parts and attachments of vertical and horizontal milling machines, to identify work-holding devices, state safety rules, and perform general maintenance.

TASKS INCLUDED IN THIS LAP:

1. Clean and lubricate a horizontal mill.
2. Clean and lubricate a vertical mill.

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User of LAP:

Included in this LAP are the answers to the pre-test and answers to the assignment sheets. If you desire to evaluate these two components, then it will be your responsibility to remove these components from the LAP prior to giving to the student. If you desire for the student to assume the responsibility for self-evaluation, then we would suggest that you leave the components contained as part of the LAP.

We hope this developmental design proves to be beneficial to you.

Sincerely,

Bob Patton, Coordinator
Curriculum and Instructional
Materials Center

BP:jd

EQUAL OPPORTUNITY/AFFIRMATIVE ACTION EMPLOYER

82-000704

MILLING MACHINES
UNIT I--INTRODUCTION TO MILLING MACHINES

LEARNING STEPS

Check the following blanks as you complete the required steps.

_____ 1.	Read	Unit and Specific Objectives, page MM-1 and 2.
_____ 2.	Complete	Introduction to Milling Machines Pretest, LAP page 9.
_____ 3.	Study	The sections of the Information Sheet, pages MM-7 through MM-41, indicated by your instructor on your Pretest. Be sure to study the transparency masters when required.
_____ 4.	Refer	To Step 22 of your Pretest. If additional study is required for any of the Information Sheet, Sections I-X, XII-XIV, or XVI-XX, continue to Learning Step 5. Otherwise, proceed to Learning Step 7.
_____ 5.	Do	LAP Assignment Sheet #1, LAP page 37.
_____ 6.	Do	LAP Assignment Sheet #2, LAP page 63.
_____ 7.	Refer	To Step 22 of your Pretest. If additional study is required for Information Sheet Section XI, continue to Learning Step 8. Otherwise, proceed to Learning Step 11.
_____ 8.	Do	Assignment Sheet #1--Complete Milling Machine Safety Test, page MM-79 through MM-81:

_____ 9.	Stop.	Have your instructor evaluate Assignment Sheet #1. If your instructor is satisfied with your progress, proceed to Learning Step 11. Otherwise, continue to Learning Step 10.
_____10.	Do	LAP Assignment Sheet #3, LAP page 87.
_____11.	Refer	To Step 22 of your Pretest. If additional study is indicated for the Information Sheet, Section XV, continue to Learning Step 12. Otherwise, proceed to Learning Step 15.
_____12.	Do	Assignment Sheet #2--Perform Calculations Necessary for Direct and Simple Indexing, page MM-83 through MM-85.
_____13.	Stop.	Have your instructor evaluate Assignment Sheet #2. If your instructor is satisfied with your progress, proceed to Learning Step 15. Otherwise, continue to Learning Step 14.
_____14.	Do	LAP Assignment Sheet #4, LAP page 92.
_____15.	Refer	To Step 22 of your Pretest. If additional study is required for the Information Sheet, Section XXI, continue to Learning Step 16. Otherwise, proceed to Learning Step 19.
_____16.	Do	Assignment Sheet #3--Calculate Machine Speed and Feed Rates, page MM-87 through MM-101.
_____17.	Stop.	Have your instructor evaluate Assignment Sheet #3. If your instructor is satisfied with your progress, proceed to Learning Step 19. Otherwise, continue to Learning Step 18.

LEARNING STEPS

_____18. Do — LAP Assignment Sheet #5, LAP page 95.

_____19. Check — The tasks below that you think you can perform without supervision.

Student Check		Instructor Initials/Date: Skilled	Moderately Skilled
_____a.	Clean and lubricate a horizontal mill (22)	_____	_____
_____b.	Clean and lubricate a vertical mill (28)	_____	_____

_____20. Discuss — Your competency in each task with your instructor. Your instructor will initial each task in which you demonstrate sufficient competency. If both tasks have been initialed by your instructor, proceed to Learning Step 33. Otherwise, continue to Learning Step 21.

_____21. Refer — To Learning Step 19a. If this task has been initialed by your instructor, proceed to Learning Step 27. Otherwise, continue to Learning Step 22.

_____22. Study — Job Sheet #1--Clean and Lubricate a Horizontal Mill, page MM-105 to MM-107.

_____23. Watch — Slide/tape presentation, "Clean and Lubricate a Horizontal Mill" (MM-I-1).

_____24. Do — Job Sheet #1-Clean and Lubricate a Horizontal Mill.

_____25.	Stop.	Have your instructor evaluate your work. If you achieve a Skilled or Moderately Skilled rating, have your instructor initial Learning Step 19a and then proceed to Learning Step 27. Otherwise, repeat Learning Steps 22 through 24 and then continue to Learning Step 26.
_____26.	Stop.	Have your instructor evaluate your work. If you achieve a Skilled or Moderately Skilled rating, have your instructor initial Learning Step 19a and then continue to Learning Step 27. If additional study is required, discuss a study program with your instructor. Once you have completed that program to your instructor's satisfaction, have your instructor initial Learning Step 19a and continue to Learning Step 27.
_____27.	Refer	To Learning Step 19b. If this task has been initialed by your instructor, proceed to Learning Step 33. Otherwise, continue to Learning Step 28.
_____28.	Study	Job Sheet #2--Clean and Lubricate a Vertical Mill, page MM-109 through 110.
_____29.	Watch	Slide/tape presentation, "Clean and Lubricate a Vertical Mill" (MM-I-2).
_____30.	Do	Job Sheet #2--Clean and Lubricate a Vertical Mill.
_____31.	Stop.	Have your instructor evaluate your work. If you achieve a Skilled or Moderately Skilled rating, have your instructor initial Learning Step 19b and then proceed to Learning Step 33. Otherwise, repeat Learning Steps 28 through 30 and then continue to Learning Step 32.

LEARNING STEPS

_____32.	Stop.	Have your instructor evaluate your work. If you achieve a Skilled or Moderately Skilled rating, have your instructor initial Learning Step 19b and then continue to Learning Step 33. If additional study is required, discuss a study program with your instructor. Once you have completed that program to your instructor's satisfaction, have your instructor initial Learning Step 19b and continue to Learning Step 33.
_____33.	Review	Information Sheet (pages MM-7 through MM-41), Assignment Sheets, and LAP Assignment Sheets.
_____34.	Take	Introduction to Milling Machines Test (see your instructor). If your score is 85 percent or above, continue to the next assigned Learning Activity Packet. Otherwise, ask your instructor about additional study requirements and possible retesting.

MILLING MACHINES
UNIT I--INTRODUCTION TO MILLING MACHINES

PRETEST

NAME _____ SCORE _____

DIRECTIONS: This pretest is to determine how much you already know about milling machines. Your performance on this pretest will not be used to determine your grade in the course. Instead, it will guide your instructor in designing this course to meet your needs. If you are unsure of the answer to a question, do not guess. Guessing may prevent you from receiving needed instruction.

1. Match terms associated with milling machines to their correct definitions. Write the correct numbers in the blanks. Terms and definitions continue on the next page.

_____a.	Mechanism used to divide the circumference of a workpiece into a given number of spaces for milling or drilling	1. Longitudinal
_____b.	Device or process that allows machine to operate outside the limits set by selectors or other machine parts	2. Driving lugs
_____c.	Method of designating milling machine spindles	3. Traversal
_____d.	Movement of table right or left through saddle dovetails	4. Standard machine taper
_____e.	Lateral or crosswise movement of saddle	5. Dividing head
_____f.	Holds table and moves in and out traversely on knee; mounted to knee	6. Trip dogs
_____g.	Metal lugs bolted to spindle to transmit power to arbor or adapter	7. Saddle
_____h.	Movable metal stops that are part of tripping mechanism used to control power movement of table, saddle, or knee by tripping the power-feed mechanism	8. Override

_____i. Parts of milling machine that support and move table up and down by elevating crank

_____j. Part of machine on which work or work-holding devices are mounted; moves longitudinally through saddle

_____k. Device that shows the required level of a lubricant for visual inspection

_____l. Machining flat, angular, circular, and tapered surfaces with a revolving cutter

_____m. Steel bolt that goes through spindle, screws into arbor or adapter, pulls arbor into spindle taper, and holds it in place with a locknut

_____n. Round machine table on which a workpiece is secured and moved in a circular path, rotating workpiece to desired angle in relation to cutter

_____o. Amount of lost motion (play) in moving parts when reversing direction of feed in a screw or gear

9. Drawbar
10. Table
11. Knee and column
12. Milling
13. Backlash
14. Sight gauge
15. Rotary table

2. Name five types of milling machines.

a. _____

b. _____

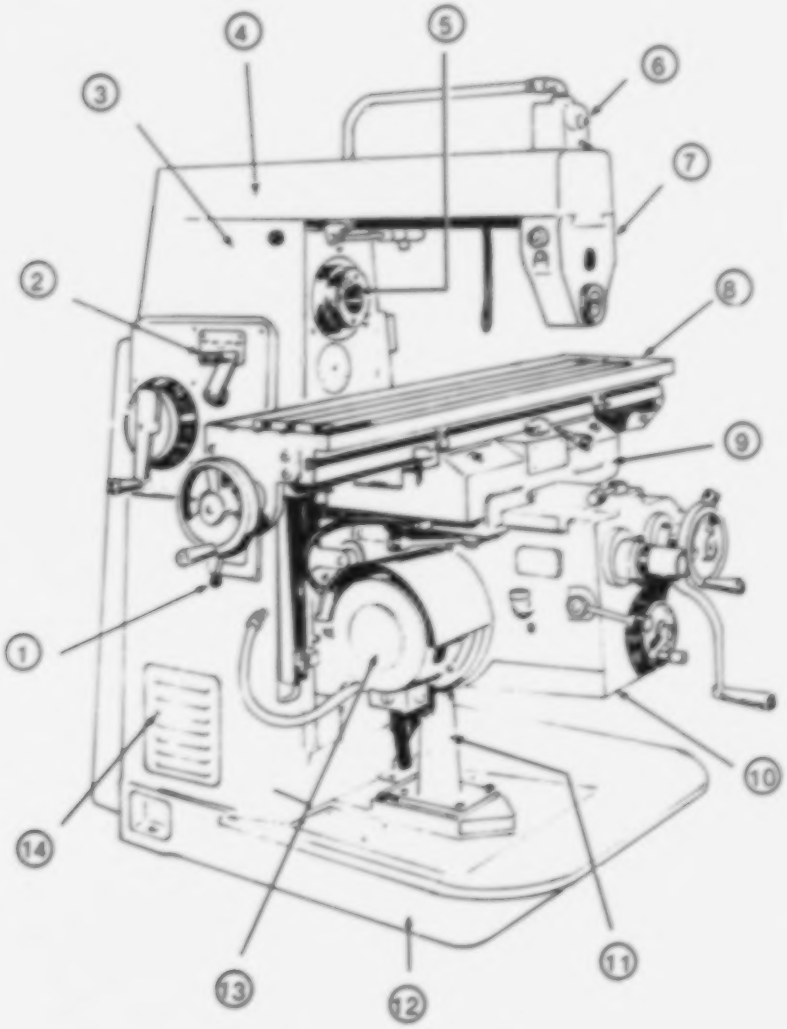
c. _____

d. _____

e. _____

3. Identify major parts of the horizontal knee-and-column mill illustrated below. Write the correct numbers in the blanks.

_____a. Spindle motor cover
_____b. Column
_____c. Knee
_____d. Overarm support
_____e. Base
_____f. Start/stop switches
_____g. Spindle reversing lever
_____h. Overarm
_____i. Table
_____j. Spindle
_____k. High/neutral/low selector lever
_____l. Saddle
_____m. Knee motor drive
_____n. Elevating screw housing



Adapted with permission of Cincinnati Milacron.

4. Match specific parts of the horizontal mill to their correct uses. Write the correct numbers in the blanks.

COLUMN

_____a.	Guides movement of ram-type overarm	1. Spindle reversing lever
_____b.	Selects revolutions per minute (rpm) at which spindle turns	2. Base
_____c.	Secure overarm to column	3. Spindle speed indicating dial
_____d.	Sets direction of spindle rotation	4. Spindle
_____e.	Permits speed mechanisms to be used in two speed ranges	5. Overarm lockbolts
_____f.	Guide and support knee, saddle, and table	6. High/neutral/low selector lever
_____g.	Aligns and drives different kinds of arbors	7. Ways
_____h.	Allows access to spindle motor for maintenance	8. Spindle motor cover
_____i.	Supports column, serves as reservoir for coolant, and provides base for elevating screw	9. Overarm slide

KNEE

_____a.	Indicate amount of cross-feed movement or elevating movement in thousandths of an inch	1. Elevating screw housing
_____b.	Provides power movement to knee for elevating, traversal, and longitudinal movements	2. Knee drive motor
_____c.	Provides support for knee; houses elevating screw machanism	3. Graduated collars
_____d.	Locks knee to column	4. Knee lock
_____e.	Overrides setting of feed indicating dial, allowing table to move at a higher rate of feed	5. Rapid traverse lever

12

_____f.	Selects rate at which machine feeds in longitudinal, traversal, or vertical travel	6. Cross-feed handwheel 7. Power elevating lever
_____g.	Moves knee assembly up or down by means of elevating screw	8. Elevating crank
_____h.	Provides for manual traverse travel of table and saddle	9. Feed indicating dial
_____i.	Moves knee assembly up or down by power at rate of feed set by feed dial	

SADDLE

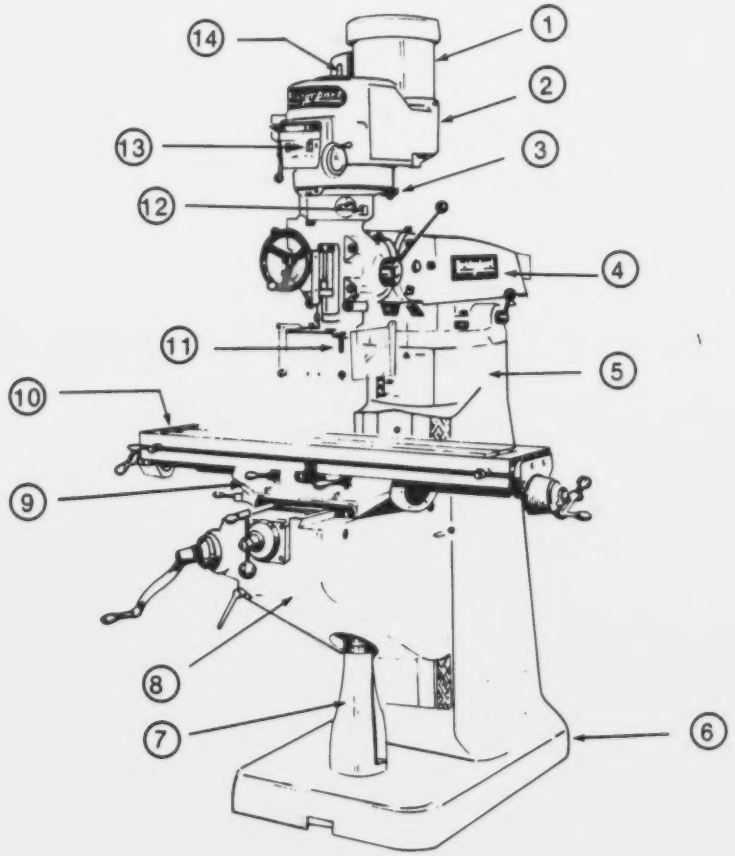
_____a.	Locks saddle to knee	1. Saddle lock
_____b.	Slide on knee; guide table by means of dovetails	2. Table clamp screws
_____c.	Engages power feed for longitudinal travel of table	3. Longitudinal-feed lever
_____d.	Lock table in position	4. Ways

TABLE

_____a.	Slide in slots on table, are adjusted to desired length of feed, and stop feed when contact is made with table engaging lever	1. T-slots 2. Positive end stops
_____b.	Allow work-holding devices to be secured to table	3. Trip dogs 4. Longitudinal-feed handwheel
_____c.	Moves table by hand	5. Graduated collar
_____d.	Indicates amount of table movement in thousandths of an inch	
_____e.	Limit maximum movement of table	

5. Identify major parts of the turret mill illustrated below. Write the correct numbers in the blanks.

_____a.	Table	_____h.	Elevating screw housing
_____b.	Spindle	_____i.	Speed indicator
_____c.	Ram	_____j.	Spindle power feed
_____d.	Motor	_____k.	Knee
_____e.	Milling head	_____l.	Column
_____f.	Saddle	_____m.	Drawbar
_____g.	High/neutral/low selector lever	_____n.	Base



Adapted with permission of Bridgeport Machines.

6. Match specific parts of the turret mill to their correct uses. Write the correct numbers in the blanks.

MILLING HEAD

_____a.	Houses spindle and bearing; moves in or out of mill head for drilling, boring, and other operations	1. Quill stop
_____b.	Engages or disengages power feed of quill	2. Quill feed direction selector
_____c.	Feeds quill by hand	3. Spindle
_____d.	Indicates speed of spindle in high or low range	4. Quill feed selector
_____e.	Feeds quill during manual movement	5. Quill lock
_____f.	Increases or decreases spindle speed	6. Micrometer adjusting nut
_____g.	Locks spindle to allow tightening or loosening of drawbar	7. Manual feed wheel
_____h.	Houses cutter holder and transmits rotary motion to cutter	8. Spindle brake
_____i.	Locks quill	9. Variable speed dial
_____j.	Sets speed range of spindle	10. Variable speed control
_____k.	Sets rate of feed for quill	11. Power-feed transmission engagement crank
_____l.	Starts and stops quill	12. Quill
_____m.	Selects direction of feed for quill (up or down)	13. High/neutral/low selector lever
_____n.	Moves with quill, trips feed control lever when depth is reached, and stops power quill movement	14. Quill feed handle
_____o.	Adjusts quill movement to a precise depth; graduated in thousandths of an inch	15. Feed control lever

RAM AND SWIVEL

_____a.	Secure head at set angle perpendicular to ram axis	1. Head swivel positioning screw
_____b.	Moves ram back and forth in swivel	2. Ram locking screw
_____c.	Moves head right or left	3. Head swivel locking screws
_____d.	Secures swivel in position	4. Swivel locking screw
_____e.	Lock position of head at set angle along ram axis	5. Head tilting lockbolts
_____f.	Secures ram in position	6. Ram positioning lever
_____g.	Allows head to be swiveled in (toward column) or out (away from column)	7. Head tilting shaft
_____h.	Allows ram and working head to be rotated to different positions	8. Swivel

TABLE

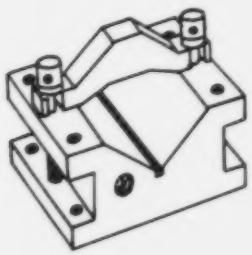
_____a.	Limit movement of table	1. Table stops
_____b.	Engages power-feed mechanism	2. Graduated collar
_____c.	Indicates amount of table movement in thousandths of an inch	3. Power-feed control lever
_____d.	Indicates and selects rate of table feed for power movement	4. Table handcranks
_____e.	Move table longitudinally	5. Power-feed attachment

SADDLE AND KNEE

_____a.	Lock position of table in saddle	1. Elevating handcrank
_____b.	Locks position of saddle on knee	2. Saddle lock
_____c.	Indicate amount of cross-feed movement or elevating movement in thousandths of an inch	3. Table locks
_____d.	Moves saddle in and out with micrometer accuracy	4. Cross-feed handcrank
_____e.	Moves knee up and down	5. Graduated collars
_____f.	Locks position of knee to column	6. Knee lock

7. Identify the working-holding devices illustrated below. Write the correct names in the blanks.

Rotary table	V-block and clamp	Indexing (dividing) head and attachments
Heavy-duty angle vise	Precision angle table (adjustable)	
Fixture	Angle plate	
Vise with swivel base	Air vise	
Hold-down clamp		



a. _____

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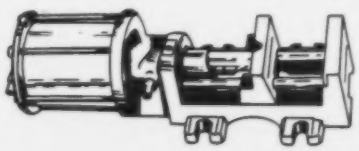

b. _____

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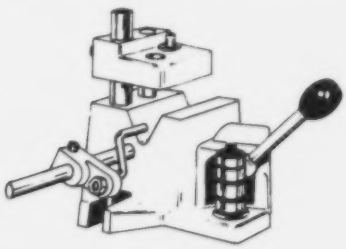

c. _____

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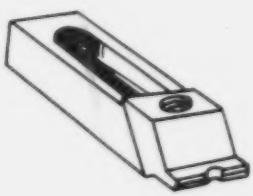

d. _____

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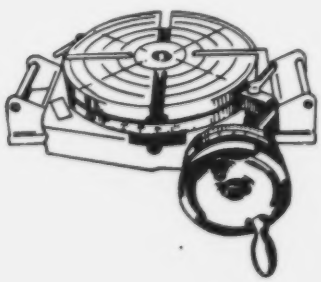

e. _____

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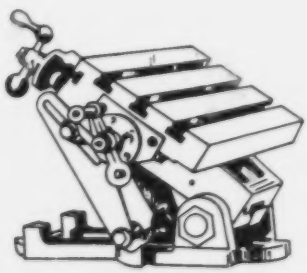
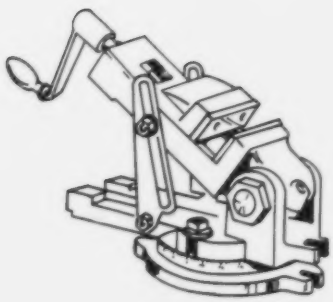
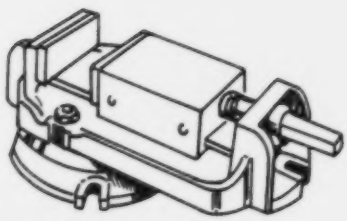


f. _____

_____

PRETEST





g. _____

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h. _____

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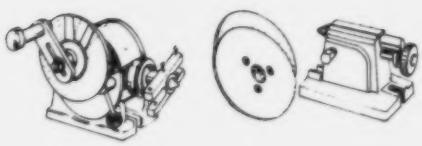

i. _____

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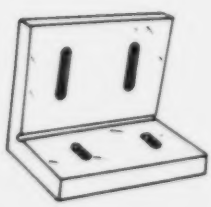
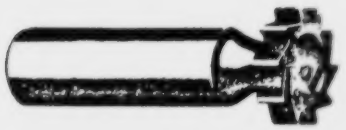


j. _____

_____

8. Identify the cutting tools illustrated below. Write the correct names in the blanks.

Four-flute end mill
Woodruff keyseat cutter
Roughing end mill
Reamer
Straight-shank drill
Shell mill cutter
Helical mill cutter
Counterbore with pilot
Staggered-tooth mill cutter
Single-angle mill cutter
Countersink
Double-end, two-flute helical end mill
Convex mill cutter
Involute gear cutter
Double-angle mill cutter
Concave mill cutter
Single-end, two-flute helical end mill
Ball-nose end mill
Corner-rounding mill cutter (radius cutter)
Plain metal-slitting saw
Corner-rounding end mill (radius-cutting end mill)
Plain mill cutter
Dovetail-cutting end mill
Side mill cutter
Insert-type end mill
Combination drill and countersink (center drill)



a. _____

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b. _____

_____

c. _____

_____

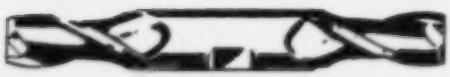
d. _____

_____

e. _____

_____

PRETEST



f. _____

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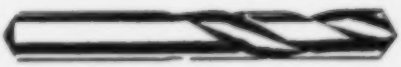

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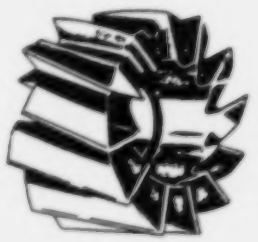

q. _____

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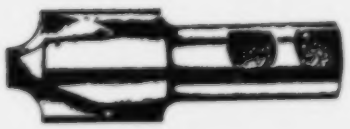
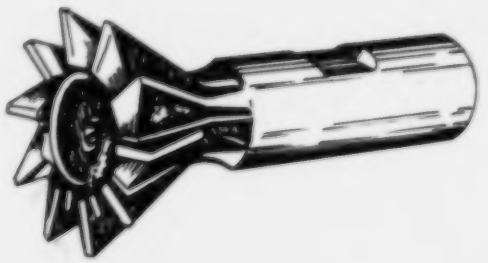


r. _____

_____



s. _____

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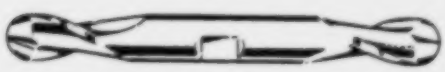


w. _____

_____

x. _____

_____

y. _____

_____

z. _____

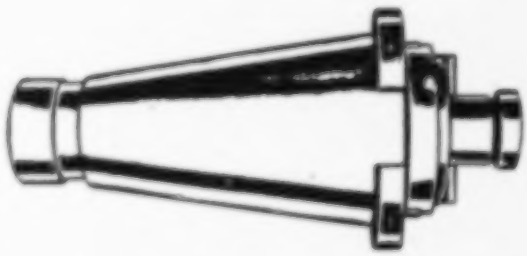
_____

22

9. Identify the toolholders for cutting tools illustrated below. Write the correct names in the blanks.

Taper adapter
Style A arbor
Shell mill arbor
Style C arbor
End mill holder
Style B arbor
Collet

a. _____



b. _____

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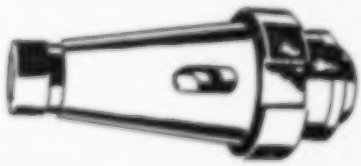


d. _____

e. _____

f. _____

g. _____

10. Match attachments to their correct uses. Write the correct numbers in the blanks.

_____a.	Indicates precise distance of axis movement, gives positive reading of precision movements, and eliminates need to consider backlash in lead screw	1. Slotting head
_____b.	Enlarges an existing hole to an exact size	2. Vertical head for horizontal mill
_____c.	Converts spindle drive so that it is perpendicular to table	3. Digital readout
_____d.	Changes axis of vertical mill spindle so that arbors can be mounted to use cutters other than end mill cutters; also used to hold drills, reamers, and mill cutters parallel to table	4. Horizontal attachment for vertical mill
_____e.	Shapes internal or external surfaces	5. Boring head
_____f.	Allows very precise rotation of workpiece for repeated cutting operations such as required for gears, splines, or cams	6. Dividing or indexing head

11. State rules for milling machine safety.

a. Rags-- _____

_____

_____

b. Setup-- _____

_____

_____

c. Cutting tools--_____

_____

_____

d. Feed--_____

_____

_____

e. Cutter rotation--_____

_____

_____

f. Measurements or adjustments--_____

_____

_____

g. Conventional or up-milling--_____

_____

_____

h. Changing parts--_____

_____

_____

i. Arbor nut and drawbar--_____

_____

_____

j. Revolving cutter--_____

_____

_____

k. Machine controls--_____

_____

_____

l. Running machine--_____

_____

_____

m. Travel levers--_____

_____

_____

n. Positioning workpiece--_____

_____

_____

o. Standing by machine--_____

_____

_____

p. Warning tags or signs--_____

_____

_____

q. Chips--_____

_____

_____

r. Compressed air--_____

_____

_____

s. Work area--_____

_____

_____

t. Heavy objects--_____

_____

_____

u. Guards--_____

_____

_____

v. Clothing--_____

_____

_____

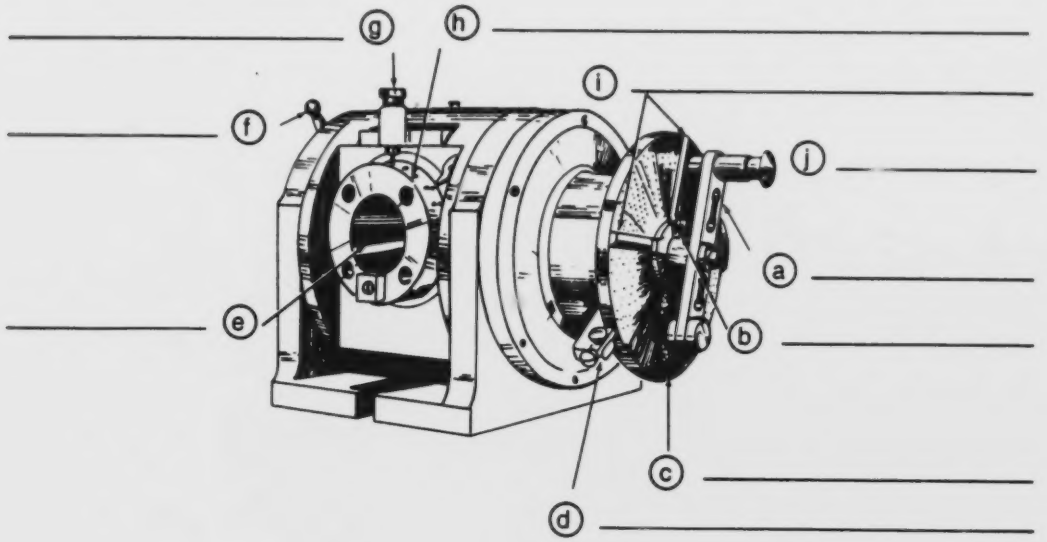
w. Safety glasses with side shields--_____

_____

_____

12. Identify the parts of the indexing or dividing head illustrated below. Write the correct names in the blanks.

Sector arms
Indexing crank
Spindle nose
Sector arm lockscrew
Spindle lock
Indexing plate stop
Direct-indexing plunger and pin
Direct-indexing holes
Indexing crank plunger pin
Indexing plate



13. Match parts of the indexing or dividing head to their correct descriptions or functions. Write the correct numbers in the blanks.

_____ a.	Locates exact movement of indexing crank	1. Indexing crank
_____ b.	Two movable arms that travel set number of holes in hole plate each time indexing crank is turned	2. Spindle nose
_____ c.	Has a machine taper that centers work-holding devices	3. Sector arm lockscrew
_____ d.	Located on spindle nose; provide for rapid indexing of parts that have divisions in multiples of 15 degrees	4. Indexing plate stop
_____ e.	Mechanical lock that prevents spindle from moving	5. Indexing crank plunger pin
_____ f.	Turns gearing mechanism of dividing head to rotate workpiece	6. Spindle lock
_____ g.	Locate and lock in correct indexing hole when direct indexing	7. Sector arms
_____ h.	Allows sector arms to be set for a particular number of holes and then locked	8. Direct-indexing plunger and pin
_____ i.	Disc with circular hole patterns used to set workpiece rotation to a specific partial turn	9. Indexing plate
_____ j.	Locks indexing plate for simple indexing; must be disengaged for direct indexing	10. Direct-indexing holes

14. List six operations performed on the dividing or indexing head.

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

15. Calculate direct and simple indexing. Show all work.

a. Calculate the direct indexing to mill flats on a 3-inch round shaft; the shaft is to have six equal sides.

Answer: _____ holes

b. Calculate the simple indexing required to cut a hexagonal gear. The dividing head has a 40:1 ratio with three indexing plates.

Plate 1 -- 16-17-18-19-20

Plate 2 -- 23-24-27-28-29

Plate 3 -- 31-32-33-35-37

Answer: _____ turn(s) _____ hole(s) in _____-hole pattern

c. Calculate the simple indexing required to cut a gear having 75 teeth. The dividing head has 40:1 ratio with a reversible indexing plate.

First side -- 24-25-28-30-34-37-38-39-41-42-43

Second side -- 46-47-49-51-53-54-57-58-59-62-66

Answer: _____ turn(s) _____ hole(s) in _____-hole pattern

16. List three reasons for using cutting fluids.

a. _____

b. _____

c. _____

17. List the basic groups of cutting fluids.

a. _____

b. _____

c. _____

d. _____

18. Match coolant application methods to their correct descriptions. Write the correct numbers in the blanks. Methods and descriptions continue on the next page.

_____a.	Coolant is applied to tool and workpiece manually by brush or oil can	1. Paste or solid application
_____b.	Jet (10 to 80 psi) applies to cutter and workpiece mist of soluble or synthetic fluid mixed with air	2. Mist system

_____c. Pressurized cold air is directed over tool and workpiece

_____d. Coolant under low pressure from one or more nozzles floods tool and workpiece; most common method of applying fluids

3. Flood cooling

4. Cold air

19. Identify coolant application methods. Write the correct names in the blanks.

Flood cooling
Mist system
Paste or solid application
Cold air

METHOD	ADVANTAGES	DISADVANTAGES
a. _____ _____	Good lubrication Good visibility of cut Excellent coolant distribution Easy to install	Limited cooling power Must be used in well-ventilated area Subject to clogging Requires air source and filter system
b. _____ _____	Good visibility of cut Easy to install Good chip control	No lubrication Expensive
c. _____ _____	Excellent lubrication and cooling Good chip removal	Expensive to use Messy Costly to install Obscures visibility of cut
d. _____ _____	Excellent for hand operations No additional equipment required Inexpensive	Dangerous when using equipment Poor cooling power Poor chip control

20. List possible causes of cutter failure and finish problems.

CHATTER (List five causes.)

a. _____

b. _____

c. _____

d. _____

e. _____

CUTTER DULLING RAPIDLY (List five causes.)

a. _____

b. _____

c. _____

d. _____

e. _____

CUTTING EDGE OVERHEATING (List five causes.)

a. _____

b. _____

c. _____

d. _____

e. _____

CUTTING EDGE CLOGGING (List five causes.)

a. _____

b. _____

c. _____

d. _____

e. _____

PRETEST

WORKPIECE MATERIAL HARDENING (List three causes.)

a. _____

b. _____

c. _____

CUTTING EDGE CHIPPING (List eight causes.)

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

g. _____

h. _____

CUTTER BREAKING (List five causes.)

a. _____

b. _____

c. _____

d. _____

e. _____

EXCESSIVE CRATERING OF CARBIDE (List three causes.)

a. _____

b. _____

c. _____

21. Calculate machine speed and feed rates for the following problems. Cutting speed and feed inches are provided. Show your work.

    a. What are the speed and feed rates when using a 1/2-inch diameter drill (HSS) to drill a hole 2 inches deep in a hard cast-iron plate?

    CS = 80 sfpm F in/rev = .007

    Speed: _____ rpm Feed: _____ ipm

    b. What are the speed and feed rates when using a 12-tooth plain mill cutter (HSS) 1/2 inch wide, 4 inches in diameter, to make a rough cut slab mill 0.150 of an inch deep in medium-carbon steel (1030)?

    CS = 90 Feed in/tooth = .006

    Speed: _____ rpm Feed: _____ ipm

22. Stop. Have your instructor evaluate your pretest and mark the area(s) below requiring additional study.

Refer to Information Sheet, Section(s)

_____I	_____VII	_____XII	_____XVII
_____II	_____VIII	_____XIII	_____XVIII
_____III	_____IX	_____XIV	_____XIX
_____IV	_____X	_____XV	_____XX
_____V	_____XI	____XVI	_____XXI
_____VI			

You came here from Learning Step 4. If none of the above sections are checked, proceed to Learning Step 7. Otherwise, continue to Learning Step 5.

MILLING MACHINES
UNIT I--INTRODUCTION TO MILLING MACHINES

LAP ASSIGNMENT SHEET #1

NAME _____ SCORE _____

1. Match terms associated with milling machines to their correct definitions. Write the correct numbers in the blanks. Definitions continue on the next page.

_____a.	Round machine table on which a workpiece is secured and moved in a circular path, rotating workpiece to desired angle in relation to cutter	1. Traversal
_____b.	Metal lugs bolted to spindle to transmit power to arbor or adapter	2. Dividing head
_____c.	Machining flat, angular, circular, and tapered surfaces with a revolving cutter	3. Rotary table
_____d.	Movement of table right or left through saddle dovetails	4. Override
_____e.	Part of machine on which work or workholding devices are mounted; moves longitudinally through saddle	5. Sight gauge
_____f.	Movable metal stops that are part of tripping mechanism used to control power movement of table, saddle, or knee by tripping the power-feed mechanism	6. Standard machine taper
_____g.	Device that shows the required level of a lubricant for visual inspection	7. Drawbar
_____h.	Parts of milling machine that support and move table up and down by elevating crank	8. Backlash
_____i.	Method of designating milling machine spindles	9. Longitudinal
_____j.	Amount of lost motion (play) in moving parts when reversing direction of feed in a screw or gear	10. Milling
		11. Knee and column
		12. Saddle
		13. Table
		14. Trip dogs
		15. Driving lugs

_____k. Steel bolt that goes through spindle, screws into arbor or adapter, pulls arbor into spindle taper, and holds it in place with a locknut

_____l. Mechanism used to divide the circumference of a workpiece into a given number of spaces for milling or drilling

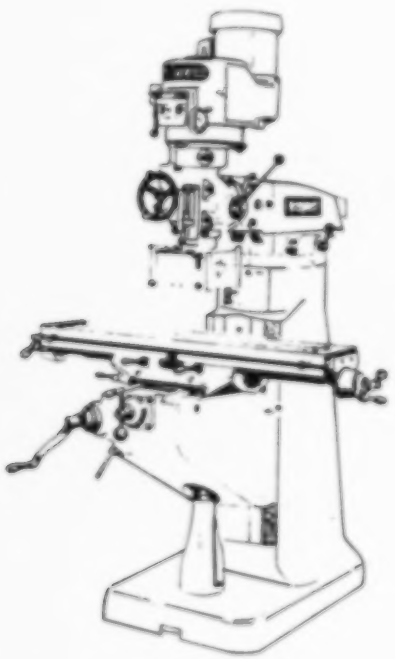
_____m. Holds table and moves in and out traversely on knee; mounted to knee

_____n. Lateral or crosswise movement of saddle

_____o. Device or process that allows machine to operate outside the limits set by selectors or other machine parts

2. Identify the types of milling machines illustrated below. Write the correct names in the blanks.

Tracer or duplicating mill
Precision jig borer
Turret mill
Horizontal mill
Bed-type manufacturing mill
Computerized mill
Vertical mill



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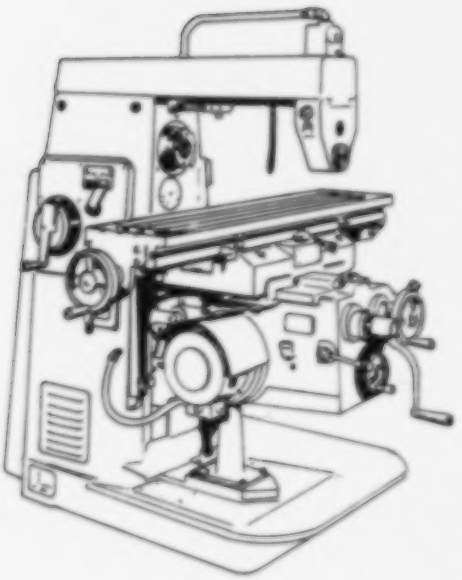
a. _____

LAP ASSIGNMENT SHEET #1



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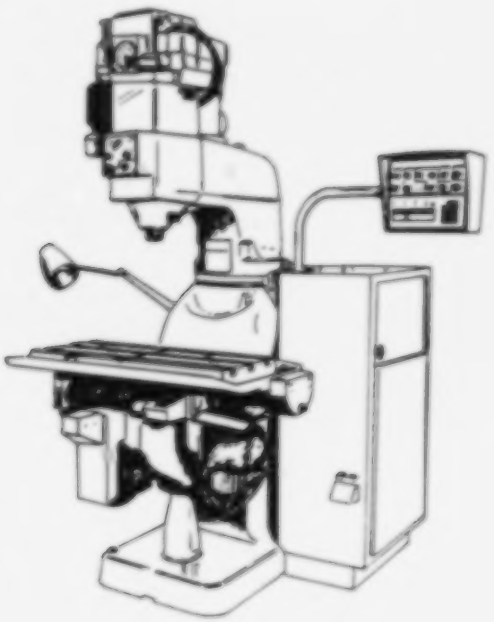

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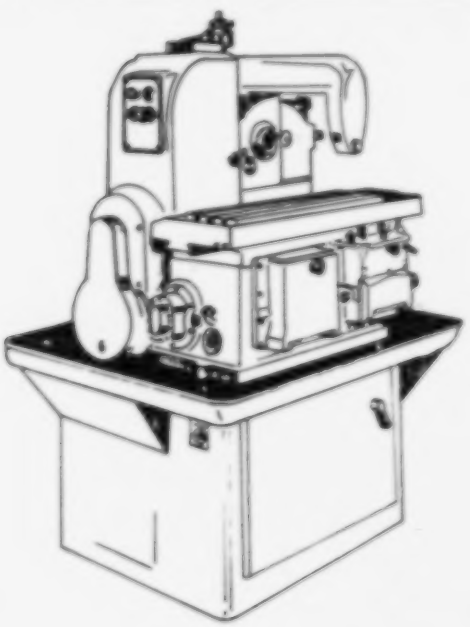

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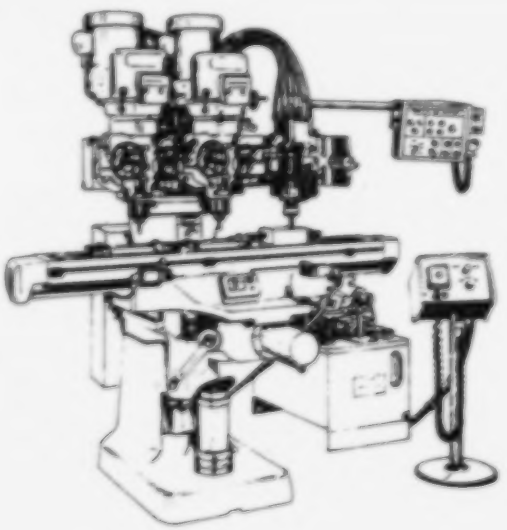

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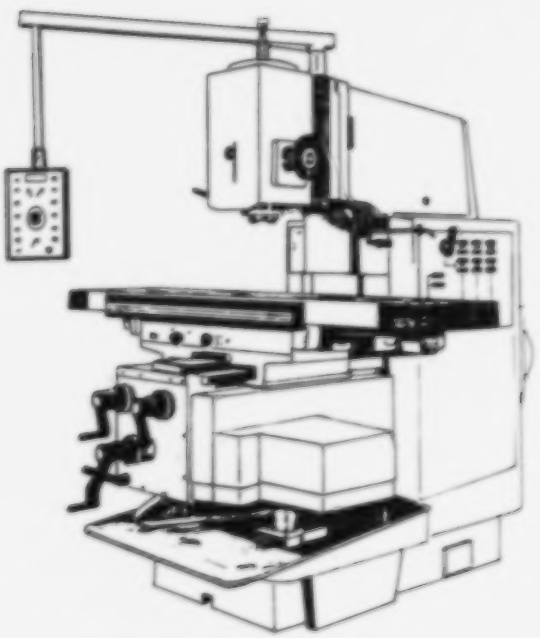
e. _____

LAP ASSIGNMENT SHEET #1



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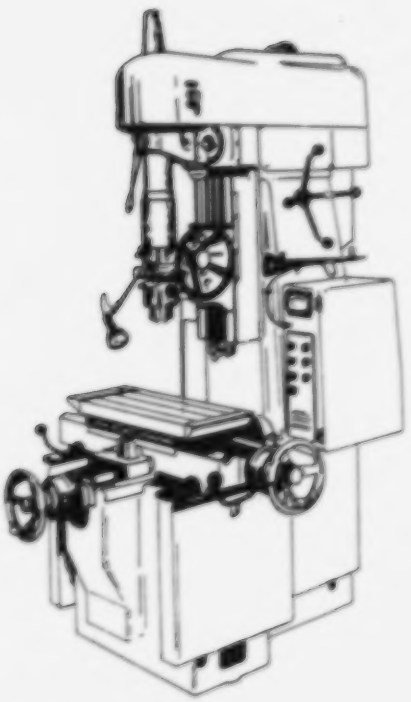


Used with permission of Moore Special Tool Company, Inc.

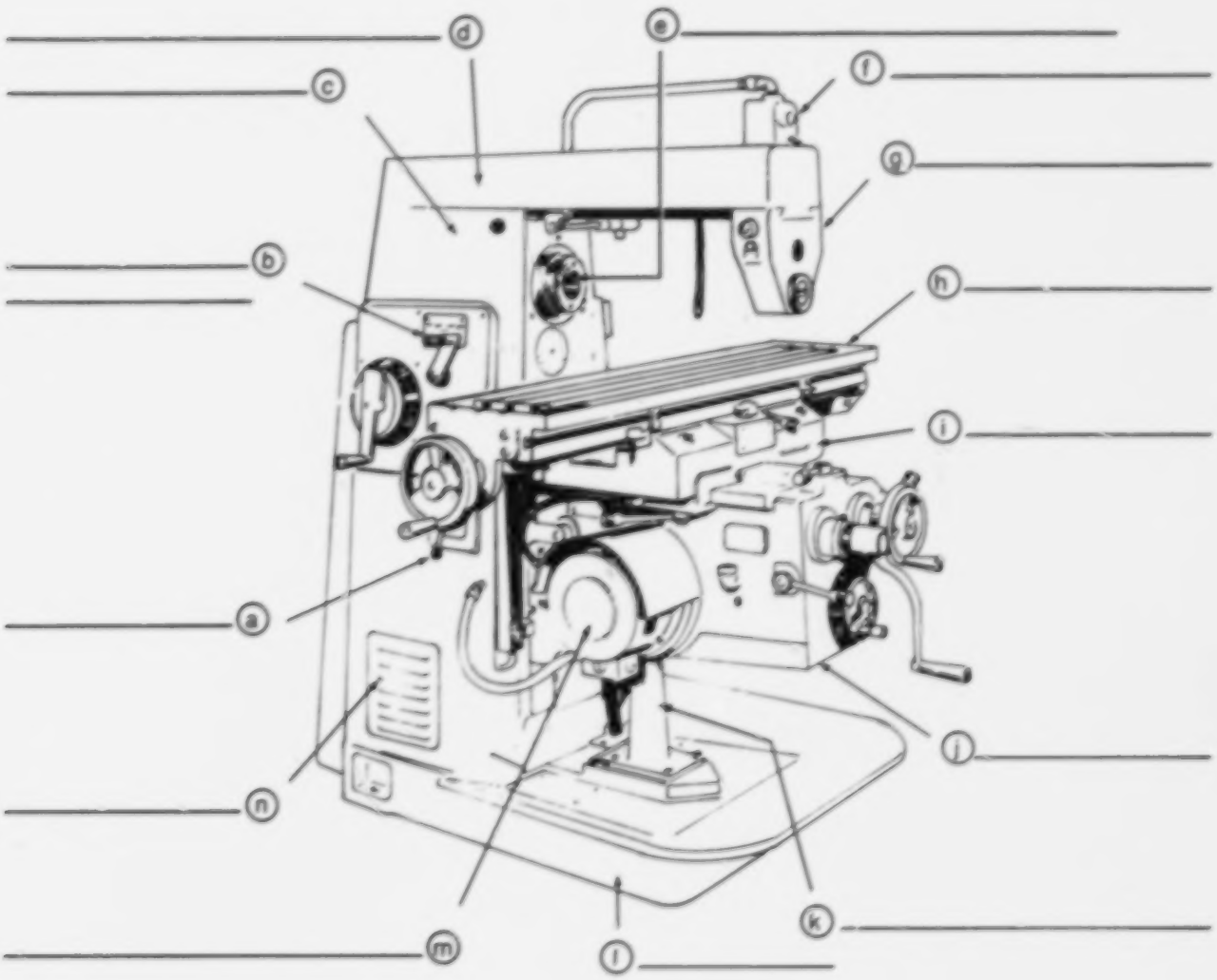
f. _____

g. _____

LAP ASSIGNMENT SHEET #1

3. Identify the major parts of the horizontal knee-and-column mill illustrated below. Write the correct names in the blanks.

Overarm	Overarm support	Spindle
Base	Spindle reversing lever	Knee motor drive
Table	Elevating screw housing	Column
Saddle	High/neutral/low selector lever	Knee
Start/stop switches		Spindle motor cover



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4. Match specific parts of the horizontal mill to their correct uses. Write the correct numbers in the blanks.

KNEE

_____a.	Indicate amount of cross-feed movement or elevating movement in thousandths of an inch	1. Feed indicating dial
_____b.	Moves knee assembly up or down by power at rate of feed set by feed dial	2. Elevating crank
_____c.	Provides for manual traverse travel of table and saddle	3. Elevating screw housing
_____d.	Provides support for knee; houses elevating screw mechanism	4. Power elevating lever
_____e.	Overrides setting of feed indicating dial, allowing table to move at a higher rate of feed	5. Cross-feed handwheel
_____f.	Moves knee assembly up or down by means of elevating screw	6. Knee lock
_____g.	Selects rate at which machine feeds in longitudinal, traversal, or vertical travel	7. Graduated collars
_____h.	Provides power movement to knee for elevating, traversal, and longitudinal movements	8. Rapid traverse lever
_____i.	Locks knee to column	9. Knee drive motor

TABLE

_____a.	Limit maximum movement of table	1. Positive end stops
_____b.	Allow work-holding devices to be secured to table	2. Trip dogs
_____c.	Indicates amount of table movement in thousandths of an inch	3. Graduated collar
_____d.	Slide in slots on table, are adjusted to desired length of feed, and stop feed when contact is made with table engaging lever	4. Longitudinal-feed handwheel
_____e.	Moves table by hand	5. T-slots

LAP ASSIGNMENT SHEET #1

COLUMN

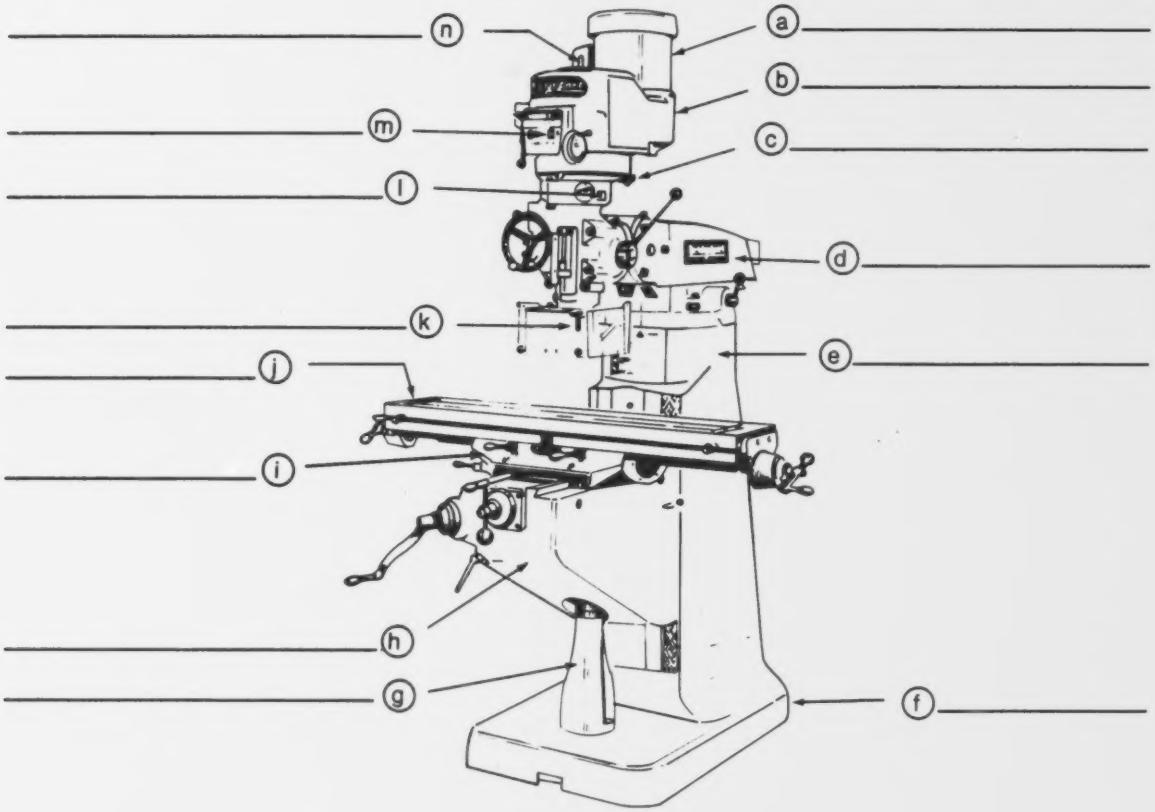
_____a.	Guides movement of ram-type overarm	1. Base
_____b.	Supports column, serves as reservoir for coolant, and provides base for elevating screw	2. Overarm slide
_____c.	Aligns and drives different kinds of arbors	3. Spindle motor cover
_____d.	Secure overarm to column	4. Spindle reversing lever
_____e.	Permits speed mechanisms to be used in two speed ranges	5. High/neutral/low selector lever
_____f.	Selects revolutions per minute (rpm) at which spindle turns	6. Spindle speed indicating dial
_____g.	Guide and support knee, saddle, and table	7. Overarm lockbolts
_____h.	Sets direction of spindle rotation	8. Ways
_____i.	Allows access to spindle motor for maintenance	9. Spindle

SADDLE

_____a.	Locks saddle to knee	1. Ways
_____b.	Engages power feed for longitudinal travel of table	2. Saddle lock
_____c.	Lock table in position	3. Longitudinal-feed lever
_____d.	Slide on knee; guide table by means of dovetails	4. Table clamp screws

5. Identify major parts of the turret mill illustrated below. Write the correct names in the blanks.

Drawbar	High/neutral/low selector lever	Saddle
Base	Knee	Elevating screw housing
Motor	Spindle	Speed indicator
Milling head	Ram	
Spindle power feed	Table	
Column		



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6. Match specific parts of the turret mill to their correct uses. Write the correct numbers in the blanks.

MILLING HEAD

_____a.	Feeds quill during manual movement	1. High/neutral/low selector lever
_____b.	Increases or decreases spindle speed	2. Power-feed transmission engagement crank
_____c.	Locks spindle to allow tightening or loosening of drawbar	3. Quill feed direction selector
_____d.	Houses cutter holder and transmits rotary motion to cutter	4. Micrometer adjusting nut
_____e.	Locks quill	5. Variable speed dial
_____f.	Sets speed range of spindle	6. Spindle brake
_____g.	Sets rate of feed for quill	7. Quill feed selector
_____h.	Starts and stops quill	8. Manual feed wheel
_____i.	Selects direction of feed for quill (up or down)	9. Feed control lever
_____j.	Moves with quill, trips feed control lever when depth is reached, and stops power quill movement	10. Quill
_____k.	Adjusts quill movement to a precise depth; graduated in thousandths of an inch	11. Spindle
_____l.	Houses spindle and bearing; moves in or out of mill head for drilling, boring, and other operations	12. Quill lock
_____m.	Engages or disengages power feed of quill	13. Variable speed control
_____n.	Feeds quill by hand	14. Quill stop
_____o.	Indicates speed of spindle in high or low range	15. Quill feed handle

SADDLE AND KNEE

_____a.	Locks position of knee to column	1. Knee lock
_____b.	Moves knee up and down	2. Elevating handcrank

LAP ASSIGNMENT SHEET #1

_____c.	Moves saddle in and out with micrometer accuracy	3. Table locks
_____d.	Indicate amount of cross-feed movement or elevating movement in thousandths of an inch	4. Saddle lock
_____e.	Lock position of table in saddle	5. Graduated collars
_____f.	Locks position of saddle on knee	6. Cross-feed handcrank

TABLE

_____a.	Move table longitudinally	1. Graduated collar
_____b.	Limit movement of table	2. Table stops
_____c.	Engages power-feed mechanism	3. Power-feed attachment
_____d.	Indicates amount of table movement in thousandths of an inch	4. Table handcranks
_____e.	Indicates and selects rate of table feed for power movement	5. Power-feed control lever

RAM AND SWIVEL

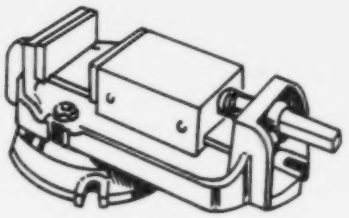
_____a.	Lock position of head at set angle along ram axis	1. Swivel locking screw
_____b.	Secures ram in position	2. Head tilting shaft
_____c.	Secure head at set angle perpendicular to ram axis	3. Head tilting lockbolts
_____d.	Moves ram back and forth in swivel	4. Head swivel positioning screw
_____e.	Allows head to be swiveled in (toward column) or out (away from column)	5. Head swivel locking screws
_____f.	Allows ram and working head to be rotated to different positions	6. Ram positioning lever
_____g.	Moves head right or left	7. Ram locking screw
_____h.	Secures swivel in position	8. Swivel

LAP ASSIGNMENT SHEET #1

7. Identify the work-holding devices illustrated below. Write the correct names in the blanks.

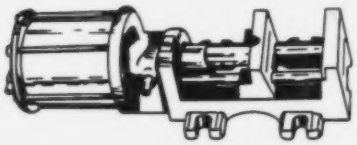
Fixture
Rotary table
Vise with swivel base
V-block and clamp
Air vise

Indexing (dividing) head and attachments
Angle plate
Precision angle table (adjustable)
Hold-down clamp
Heavy-duty angle vise



a. _____

_____



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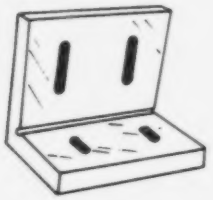

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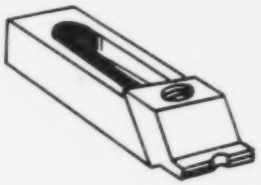
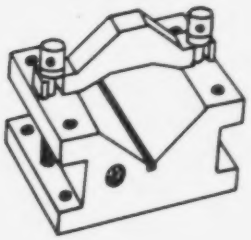


d. _____

_____



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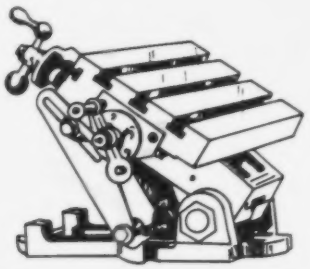
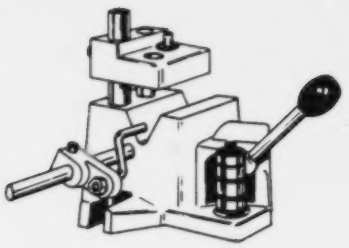


f. _____

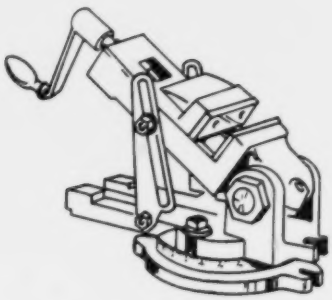
_____

LAP ASSIGNMENT SHEET #1



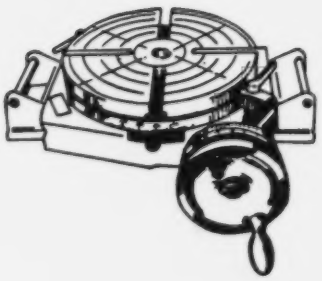
g. _____

_____



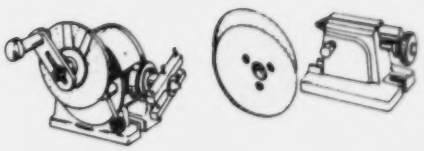
h. _____

_____



i. _____

_____



j. _____

_____

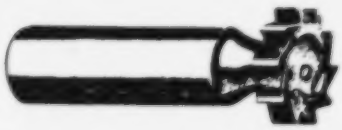
LAP ASSIGNMENT SHEET #1

8. Identify the cutting tools illustrated below. Write the correct names in the blanks.

Combination drill and countersink
(center drill)
Woodruff keyseat cutter
Single-end, two-flute helical end mill
Reamer
Roughing end mill
Ball-nose end mill

a. _____

_____



b. _____

_____

c. _____

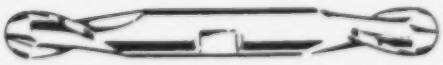
_____

d. _____

_____

e. _____

_____



f. _____

_____

LAP ASSIGNMENT SHEET #1

Involute gear cutter
Staggered-tooth mill cutter
Corner-rounding mill cutter
(radius cutter)

Insert-type end mill
Concave mill cutter
Countersink

g. _____

_____

h. _____

_____

i. _____

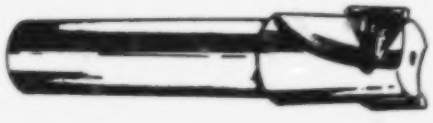
_____

j. _____

_____

k. _____

_____



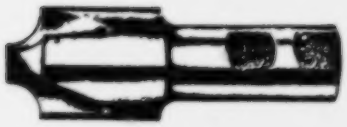
l. _____

_____

LAP ASSIGNMENT SHEET #1

Corner-rounding end mill
(radius-cutting end mill)
Dovetail-cutting end mill

Shell mill cutter
Helical mill cutter
Counterbore with pilot



m. _____

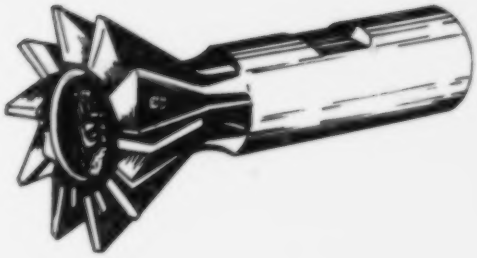
_____

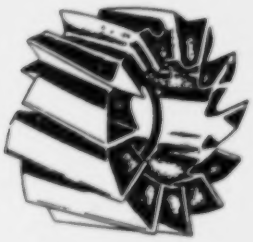
n. _____

_____

o. _____

_____





p. _____

_____

q. _____

_____

LAP ASSIGNMENT SHEET #1

Four-flute end mill
Double-end, two-flute helical end mill
Plain metal-slitting saw
Single-angle mill cutter
Double-angle mill cutter
Plain mill cutter
Convex mill cutter
Side mill cutter
Straight-shank drill

r. _____ _____

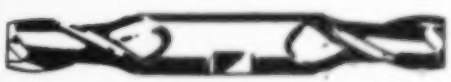
s. _____ _____

t. _____ _____

u. _____ _____

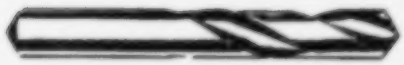
v. _____ _____

w. _____ _____



x. _____ _____

y. _____ _____



z. _____

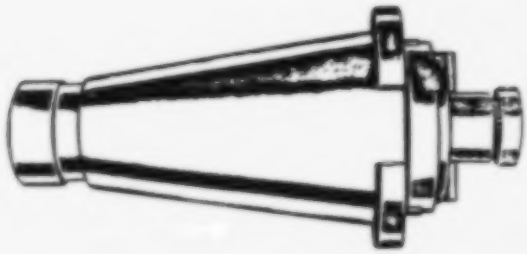
_____

9. Identify the toolholders for cutting tools illustrated below. Write the correct names in the blanks.

Style B arbor
Shell mill arbor
Taper adapter
Collet
End mill holder
Style C arbor
Style A arbor

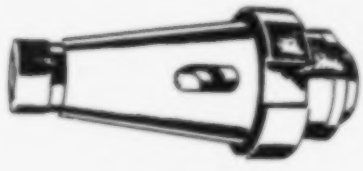
a. _____

b. _____



c. _____

d. _____



e. _____

f. _____ g. _____

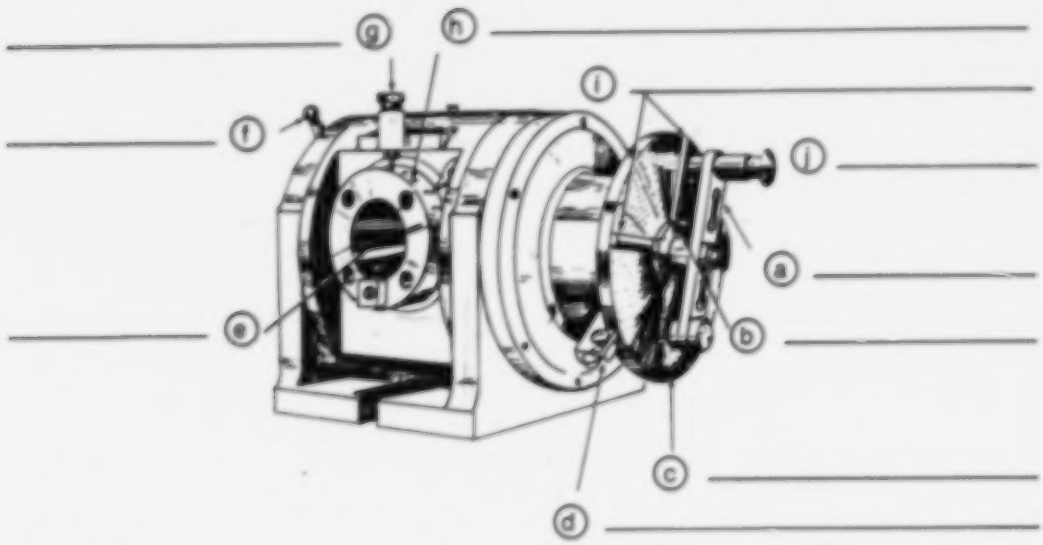
10. Match attachments to their correct uses. Write the correct numbers in the blanks.

_____a.	Changes axis of vertical mill spindle so that arbors can be mounted to use cutters other than end mill cutters; also used to hold drills, reamers, and mill cutters parallel to table	1. Digital readout
_____b.	Shapes internal or external surfaces	2. Vertical head for horizontal mill
_____c.	Allows very precise rotation of workpiece for repeated cutting operations such as required for gears, splines, or cams	3. Horizontal attachment for vertical mill
_____d.	Indicates precise distance of axis movement, gives positive reading of precision movements, and eliminates need to consider backlash in lead screw	4. Boring head
_____e.	Enlarges an existing hole to an exact size	5. Dividing or indexing head
_____f.	Converts spindle drive so that it is perpendicular to table	6. Slotting head

LAP ASSIGNMENT SHEET #1

11. Identify the parts of the indexing or dividing head illustrated below. Write the correct names in the blanks.

Spindle nose	Indexing crank	Spindle lock
Indexing plate	Sector arms	Sector arm lock-screw
Indexing plate stop	Indexing crank plunger pin	Direct-indexing plunger and pin
Direct-indexing holes		



12. List operations performed on a dividing or indexing head.

CUTTING

a. _____ b. _____

c. _____ d. _____

MACHINING

a. _____

b. _____

DRILLING-- _____

RULING OR GRADUATING-- _____

13. Fill in the blanks to complete the following statements concerning reasons for using cutting fluids.

    a. To keep workpiece and tool _____

    b. To reduce _____ by lubrication

    c. To help prevent chips from _____ to cutter

    d. To _____ chips away from workpiece and cutter

14. Match basic groups of cutting fluids to their correct examples. Write the correct numbers in the blanks.

_____a.	Solutions or synthetic emulsions, Code #6, Code #7	1. Emulsifiable oils
_____b.	Soluble oil, Code #4, sulfurized soluble oil, Code #5	2. Special cutting fluids
_____c.	Mineral oil, Code #3, sulfo-chlorinated oil, Code #2	3. Cutting oils
_____d.	#80 honing oil, #87 cutting fluid for copper	4. Chemical and synthetic emulsions

15. Name the coolant application method for each of the following descriptions. Write the correct names in the blanks.

    a. _____--Coolant is applied to tool and workpiece manually by brush or oil can

    b. _____--Coolant under low pressure from one or more nozzles floods workpiece; most common method of applying fluids

    c. _____--Pressurized cold air is directed over tool and workpiece

    d. _____--Jet (10 to 80 psi) applies to cutter and workpiece mist of soluble or synthetic fluid mixed with air

16. List two advantages and two disadvantages for each of the following methods for applying coolant.

FLOOD COOLING

a. Advantages 1) _____

2) _____

b. Disadvantages 1) _____

2) _____

MIST SYSTEM

a. Advantages 1) _____

2) _____

b. Disadvantages 1) _____

2) _____

PASTE OR SOLID APPLICATION

a. Advantages 1) _____

2) _____

b. Disadvantages 1) _____

2) _____

COLD AIR

a. Advantages 1) _____

2) _____

b. Disadvantages 1) _____

2) _____

17. Select from the lists below to identify possible causes of cutter failure and finish problems. Write an "X" in the blank before each correct answer.

CHATTER

_____a. Excessive revolutions per minute (rpm)

_____b. Inadequate coolant at cut

_____c. Cutter not properly positioned

_____d. Dull cutter

_____e. Cut too deep

_____f. Cutter slipping

_____g. Workpiece not properly supported

_____h. Excessive feed

_____i. Chips being recut

_____j. Workpiece not held rigidly

CUTTING EDGE OVERHEATING

_____a. Incorrect cutter

_____b. Excessive revolutions per minute (rpm)

_____c. Inadequate coolant at cut

_____d. Chatter

_____e. Workpiece not held rigidly

_____f. Incorrect coolant

_____g. Dull cutter

_____h. Excessive feed

_____i. Cutter slipping

_____j. Cutter ground improperly

_____k. Bent arbor

_____l. Cut too deep

LAP ASSIGNMENT SHEET #1

CUTTER BREAKING

_____a. Dull cutter

_____b. Cutter ground improperly

_____c. Cutter slipping

_____d. Loose gibs or play in table

_____e. Workpiece not held rigidly

_____f. Outboard arbor bushing loose

_____g. Cut too deep

_____h. Excessive revolutions per minute (rpm)

_____i. Excessive feed

_____j. Incorrect machine operation

CUTTER DULLING RAPIDLY

_____a. Cutter ground improperly

_____b. Incorrect coolant

_____c. Cut too deep

_____d. Chatter

_____e. Excessive revolutions per minute (rpm)

_____f. Low revolutions per minute (rpm)

_____g. Excessive feed

_____h. Incorrect feed (high or low)

_____i. Not enough cutting edges

_____j. Incorrect cutter

_____k. Too many teeth or flutes in cutter

_____l. Inadequate coolant at cut

LAP ASSIGNMENT SHEET #1

EXCESSIVE CRATERING OF CARBIDE

_____a. Excessive revolutions per minute (rpm)

_____b. Dull cutter

_____c. Incorrect cutter

_____d. Excessive feed

_____e. Cut too deep

_____f. Cutter ground improperly

CUTTING EDGE CHIPPING

_____a. Bent arbor

_____b. Excessive revolutions per minute (rpm)

_____c. Workpiece not held rigidly

_____d. Loose gibs or play in table

_____e. Low revolutions per minute (rpm)

_____f. Excessive feed

_____g. Cutter slipping

_____h. Chips being recut

_____i. Incorrect cutter

_____j. Inadequate coolant at cut

_____k. Chatter

_____l. Outboard arbor bushing loose

_____m. Not enough cutting edges

_____n. Coolant flow direction wrong

_____o. Cutter ground improperly

_____p. Cut too deep

LAP ASSIGNMENT SHEET #1

CUTTING EDGE CLOGGING

_____a. Too few teeth or flutes in cutter

_____b. Too many teeth or flutes in cutter

_____c. Incorrect coolant

_____d. Chatter

_____e. Excessive revolutions per minute (rpm)

_____f. Inadequate coolant at cut

_____g. Coolant flow direction wrong

_____h. Low revolutions per minute (rpm)

_____i. Workpiece not properly supported

_____j. Excessive feed

_____k. Incorrect cutter

_____l. Dull cutter

_____m. Cut too deep

WORKPIECE MATERIAL HARDENING

_____a. Excessive feed

_____b. Cutter slipping

_____c. Dull cutter

_____d. Excessive revolutions per minute (rpm)

_____e. Low revolutions per minute (rpm)

_____f. Inadequate coolant at cut

_____g. Chatter

_____h. Incorrect coolant

18. Stop. Have your instructor evaluate your assignment sheet and mark the area(s) below requiring additional study.

Refer to Information Sheet, Section(s)

_____I	_____II	_____III	_____IV	_____V
_____VI	_____VII	_____VIII	_____IX	_____X
_____XII	_____XIV	_____XVI	_____XVII	_____XVIII
_____XIX	_____XX			

If none of the above sections are checked, proceed to Learning Step 7. Otherwise, study the required section(s) of the Information Sheet and then continue to Learning Step 7.

MILLING MACHINES
UNIT I--INTRODUCTION TO MILLING MACHINES

LAP ASSIGNMENT SHEET #2

NAME _____ SCORE _____

1. Fill in the blanks to complete definitions of terms associated with milling machines.

   a. DIVIDING HEAD--Mechanism used to divide the _____ of a workpiece into a given number of _____ for milling or drilling

   b. STANDARD MACHINE TAPER--Method of designating milling machine _____

   c. TABLE--Part of machine on which work or _____ devices are mounted; moves _____ through saddle

   d. ROTARY TABLE--Round machine table on which a workpiece is secured and moved in a _____ path, rotating workpiece to desired angle in relation to _____

   e. MILLING--Machining flat, angular, circular, and tapered surfaces with a _____ _____

   f. SIGHT GAUGE--Device that shows the required level of a _____ for visual inspection

   g. SADDLE--Holds _____ and moves in and out _____ on knee; mounted to knee

   h. TRIP DOGS--Movable metal _____ that are part of tripping mechanism used to control power movement of table, saddle, or knee by tripping the _____ mechanism

i. LONGITUDINAL--Movement of table _____ or _____ through saddle dovetails

j. TRAVERSAL--_____ or _____ movement of saddle

k. KNEE AND COLUMN--Parts of milling machine that support and move table _____ and _____ by elevating crank

l. BACKLASH--Amount of _____ _____ (play) in moving parts when reversing _____ of _____ in a screw or gear

m. DRAWBAR--_____ _____ that goes through spindle, screws into arbor or adapter, pulls arbor into spindle taper, and holds it in place with a locknut

n. OVERRIDE--Device or process that allows machine to operate outside the limits set by _____ or other machine parts

o. DRIVING LUGS--Metal lugs bolted to spindle to _____ _____ to arbor or adapter

2. Name types of milling machines.

a. _____

b. _____

c. _____

d. _____

e. _____

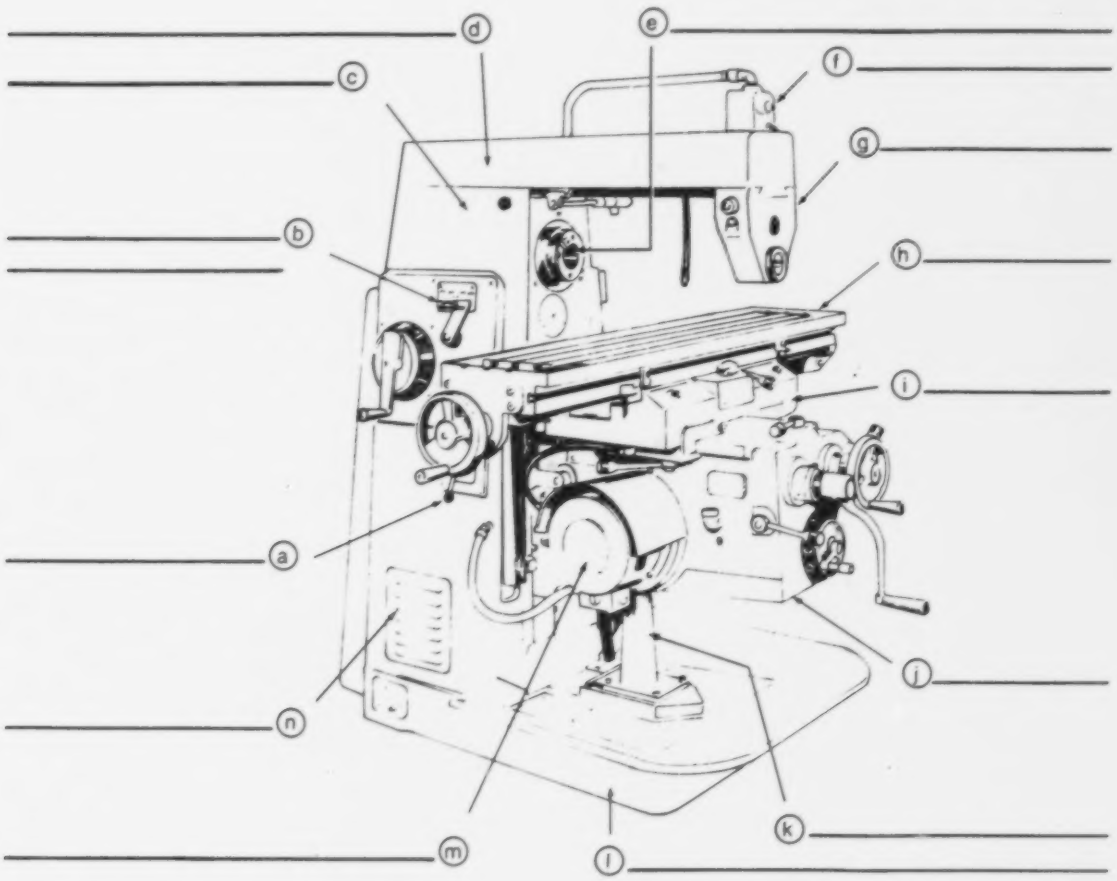
f. _____

g. _____ _____

LAP ASSIGNMENT SHEET #2

3. Identify major parts of the horizontal knee-and-column mill illustrated below. Write the correct names in the blanks.

High/neutral/low selector lever	Elevating screw housing
Column	Knee
Spindle motor cover	Start/stop switches
Overarm	Saddle
Table	Spindle reversing lever
Overarm support	Spindle
Base	Knee motor drive



Adapted with permission of Cincinnati Milacron.

4. Fill in the blanks to complete statements concerning the uses of specific parts of the horizontal mill.

COLUMN

a. BASE--Supports _____, serves as a reservoir for _____, and provides base for elevating screw

b. SPINDLE MOTOR COVER--Allows access to _____ _____ for maintenance

c. OVERARM SLIDE--Guides movement of _____ overarm

d. SPINDLE--Aligns and drives different kinds of _____

e. SPINDLE REVERSING LEVER--Sets direction of spindle _____

f. WAYS-- _____ and _____ knee, saddle, and table

g. HIGH/NEUTRAL/LOW SELECTOR LEVER--Permits _____ mechanisms to be used in two speed ranges

h. OVERARM LOCKBOLTS--Secure overarm to _____

i. SPINDLE SPEED INDICATING DIAL--Selects _____ _____ _____ _____ at which spindle turns

KNEE

a. ELEVATING CRANK--Moves _____ _____ up or down by means of an elevating screw

b. RAPID TRAVERSE LEVER--_____ setting of feed indicating dial, allowing table to move at a higher rate of _____

c. GRADUATED COLLARS--Indicate amount of _____ movement or _____ movement in thousandths of an inch

LAP ASSIGNMENT SHEET #2

d. CROSS-FEED HANDWHEEL--Provides for _____ _____ travel of table and saddle

e. KNEE LOCK--Locks knee to _____

f. FEED INDICATING DIAL--Selects _____ at which machine feeds in longitudinal, traversal, or vertical travel

g. ELEVATING SCREW HOUSING--Provides support for _____; houses _____ _____ mechanism

h. POWER ELEVATING LEVER--Moves knee assembly _____ or _____ by power at rate of feed set by feed dial

i. KNEE DRIVE MOTOR--Provides _____ _____ to knee for elevating, traversal, and longitudinal movements

SADDLE

a. TABLE CLAMP SCREWS--_____ table in position

b. SADDLE LOCK--Locks saddle to _____

c. WAYS--_____ on knee; guide table by means of _____

d. LONGITUDINAL-FEED LEVER--Engages _____ _____ for longitudinal travel of table

TABLE

a. POSITIVE END STOPS--Limit _____ _____ of table

b. T-SLOTS--Allow _____ devices to be secured to table

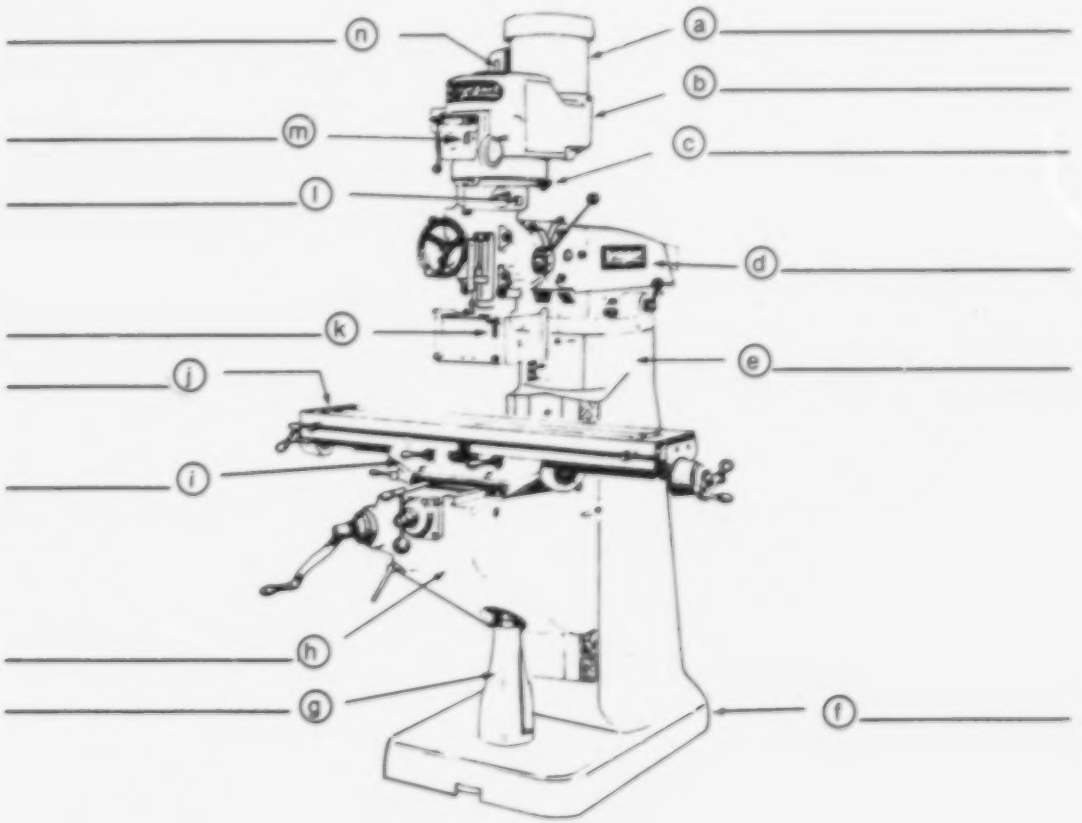
c. GRADUATED COLLAR--Indicates amount of _____ _____ in thousandths of an inch

d. LONGITUDINAL-FEED HANDWHEEL--Moves _____ by hand

e. TRIP DOGS--Slide in _____ on table, are adjusted to desired length of feed, and _____ feed when contact is made with _____ _____ lever

5. Identify major parts of the turret mill illustrated below. Write the correct names in the blanks.

Saddle
Knee
Spindle power feed
Speed indicator
Table
Base
Column
Milling head
Elevating screw housing
Spindle
Motor
High/neutral/low selector lever
Ram
Drawbar



Adapted with permission of Bridgeport Machines.

LAP ASSIGNMENT SHEET #2

6. Fill in the blanks to complete the following statements concerning the specific parts of the turret mill and their correct uses.

MILLING HEAD

a. VARIABLE SPEED DIAL--Indicates speed of _____ in high or low range

b. QUILL--Houses _____ and _____; moves in or out of mill head for drilling, boring, and other operations

c. QUILL LOCK--Locks _____

d. HIGH/NEUTRAL/LOW SELECTOR LEVER--Sets speed range of _____

e. MICROMETER ADJUSTING NUT--Adjusts quill _____ to a precise depth; graduated in thousandths of an inch

f. QUILL FEED HANDLE--Feeds quill during _____ movement

g. SPINDLE--Houses _____ _____ and transmits rotary motion to cutter

h. QUILL STOP--Moves with quill, trips _____ _____ lever when depth is reached, and stops power quill movement

i. VARIABLE SPEED CONTROL--Increases or decreases _____ speed

j. QUILL FEED SELECTOR--Sets _____ of feed for quill

k. MANUAL FEED WHEEL--Feeds _____ by hand

l. POWER-FEED TRANSMISSION ENGAGEMENT CRANK--Engages or disengages power feed of _____

m. SPINDLE BRAKE--Locks spindle to allow tightening or loosening of _____

LAP ASSIGNMENT SHEET #2

n. QUILL FEED DIRECTION SELECTOR--Selects direction of feed for quill (_____ or _____)

o. FEED CONTROL LEVER--_____ and _____ quill

RAM AND SWIVEL

a. HEAD SWIVEL POSITIONING SCREW--Moves head _____ or _____

b. SWIVEL LOCKING SCREW-- _____ swivel in position

c. HEAD TILTING SHAFT--Allows head to be swiveled in (toward _____) or out (away from _____)

d. RAM POSITIONING LEVER--Moves ram _____ and _____ in swivel

e. SWIVEL--Allows ram and working head to be _____ to different positions

f. HEAD TILTING LOCKBOLTS--Lock position of head at set angle along _____ _____

g. RAM LOCKING SCREW--Secures ram in _____

h. HEAD SWIVEL LOCKING SCREWS--Secure head at set angle _____ to ram axis

TABLE

a. POWER-FEED ATTACHMENT-- _____ and _____ rate of table feed for power movement

b. TABLE HANDCRANKS--Move table _____

c. TABLE STOPS--Limit _____ of table

d. POWER-FEED CONTROL LEVER--_____ power-feed mechanism

e. GRADUATED COLLAR--Indicates amount of _____ _____ in thousandths of an inch

SADDLE AND KNEE

a. ELEVATING HANDCRANK--Moves knee _____ and _____

b. KNEE LOCK--Locks position of knee to _____

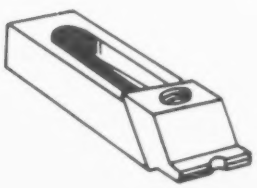
c. TABLE LOCKS--Lock position of table in _____

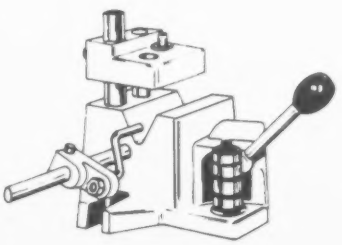
d. GRADUATED COLLARS--Indicate amount of _____ movement or _____ movement in thousandths of an inch

e. CROSS-FEED HANDCRANK--Moves _____ in and out with micrometer accuracy

f. SADDLE LOCK--Locks position of saddle on _____

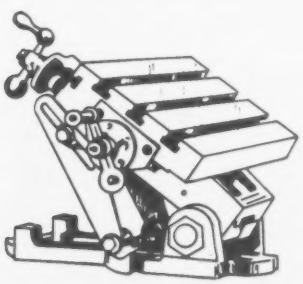
7. Label the work-holding devices illustrated below

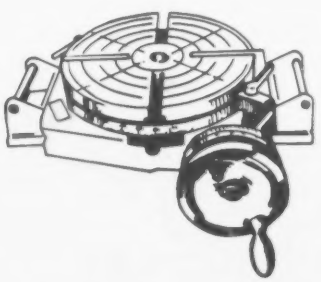




a. _____ b. _____

_____ _____

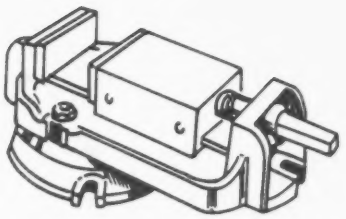




c. _____ d. _____

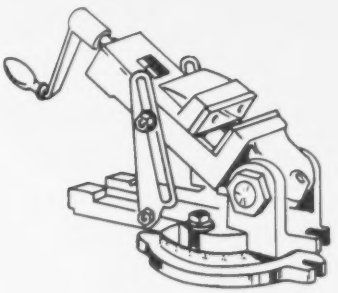
_____ _____

LAP ASSIGNMENT SHEET #2



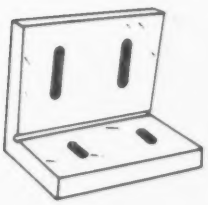
e. _____

_____



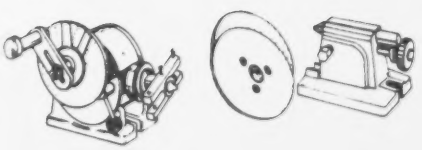
f. _____

_____



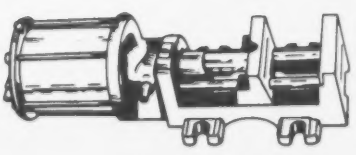
g. _____

_____



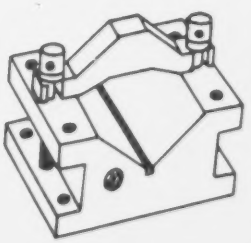
h. _____

_____



i. _____

_____



j. _____

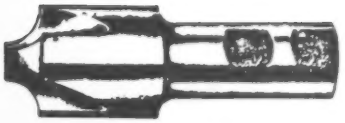
_____

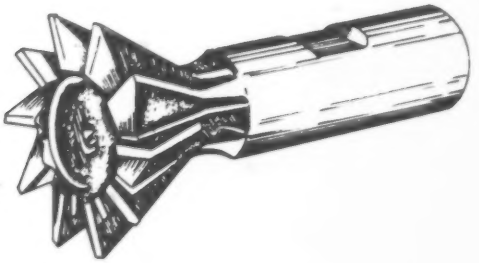
LAP ASSIGNMENT SHEET #2

8. Label the cutting tools illustrated below.

a. _____

_____



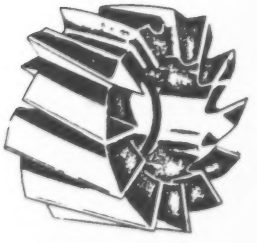


b. _____

_____

c. _____

_____



d. _____

_____

e. _____

_____

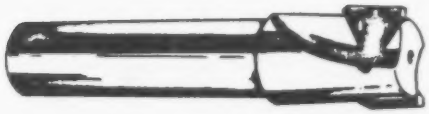
LAP ASSIGNMENT SHEET #2

f. _____

_____

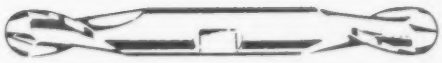
g. _____

_____



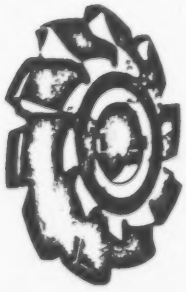
h. _____

_____



i. _____

_____



j. _____

_____

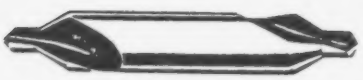
k. _____

_____

LAP ASSIGNMENT SHEET #2

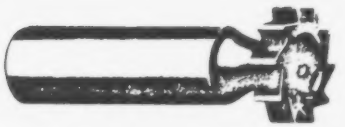
l. _____

_____



m. _____ n. _____

_____ _____



o. _____ p. _____

_____ _____

q. _____ r. _____ s. _____

_____ _____ _____

LAP ASSIGNMENT SHEET #2

t. _____

_____

u. _____

_____

v. _____

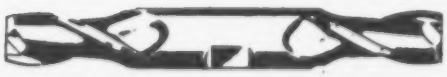
_____

w. _____

_____

x. _____

_____



y. _____

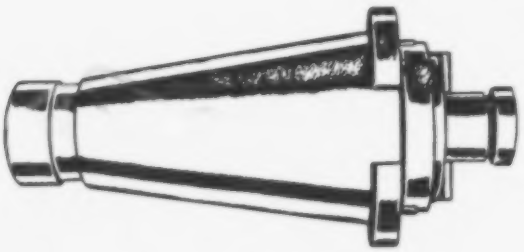
_____

z. _____

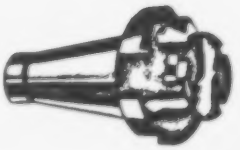
_____

LAP ASSIGNMENT SHEET #2

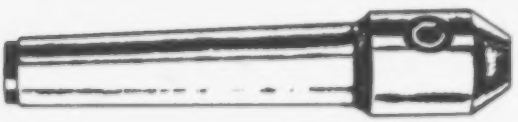
9. Label toolholders for cutting tools illustrated below.

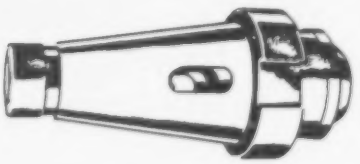


a. _____



b. _____ c. _____



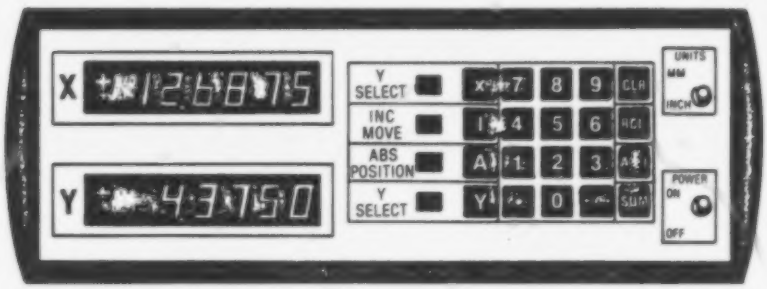


d. _____ e. _____

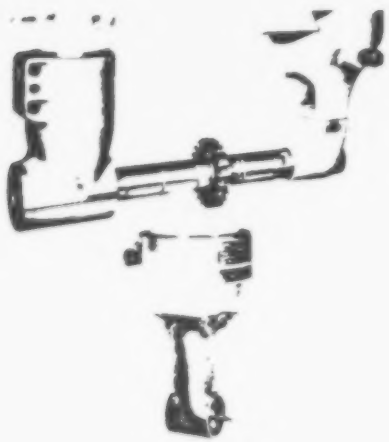
f. _____ g. _____

LAP ASSIGNMENT SHEET #2

10. Label attachments illustrated below.

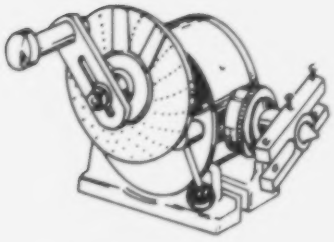


a. _____--Indicates precise distance of axis movement, gives positive reading of precision movements, and eliminates need to consider backlash in lead screw

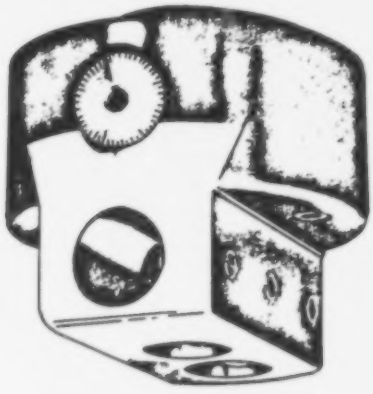


b. _____--Changes axis of vertical mill spindle so that arbors can be mounted to use cutters other than end mill cutters; also used to hold drills, reamers, and mill cutters parallel to table

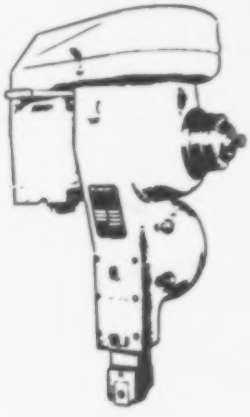
LAP ASSIGNMENT SHEET #2



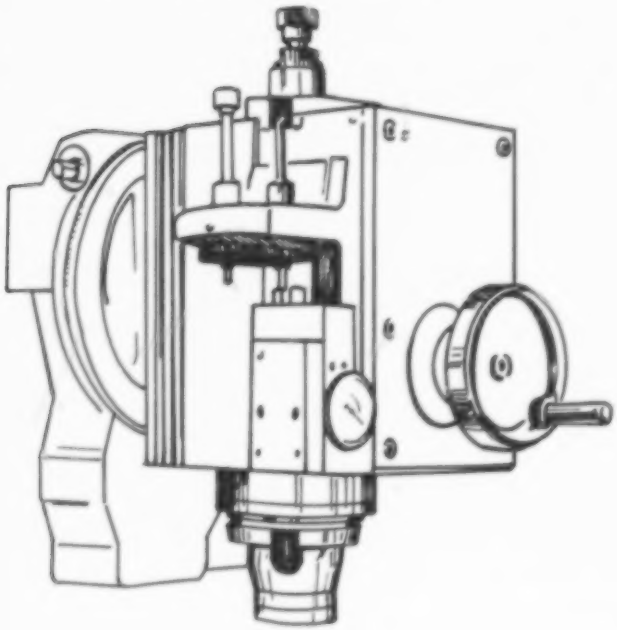
c. _____--Allows very precise rotation of work-piece for repeated cutting operations such as required for gears, splines, or cams



d. _____--Enlarges an existing hole to an exact size

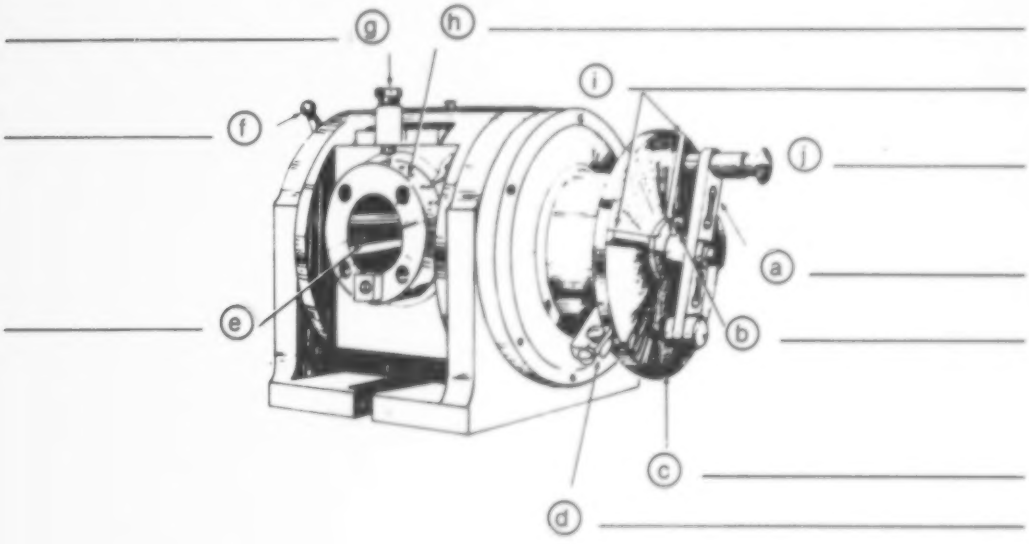


e. _____--Shapes internal or external surfaces



f. _____--Converts spindle drive so that it is perpendicular to table

11. Label parts of the indexing or dividing head illustrated below.



LAP ASSIGNMENT SHEET #2

12. Fill in the blanks to complete descriptions or functions of parts of the indexing or dividing head.

a. _____ ARMS--Two movable arms that travel set number of holes in hole plate each time indexing crank is turned

b. INDEXING CRANK--Turns _____ mechanism of dividing head to rotate workpiece

c. SPINDLE _____--Has a machine taper that centers work-holding devices

d. SPINDLE _____--Mechanical lock that prevents spindle from moving

e. INDEXING PLATE STOP--Locks indexing plate for _____ indexing; must be _____ for direct indexing

f. INDEXING CRANK PLUNGER PIN--Locates _____ _____ of indexing crank

g. DIRECT-INDEXING PLUNGER AND PIN--Locate and _____ _____ correct indexing hole when direct indexing

h. SECTOR ARM LOCKSCREW--Allows sector arms to be set for a particular _____ of holes and then locked

i. DIRECT-INDEXING HOLES--Located on _____ _____; provide for rapid indexing of parts that have divisions in multiples of _____ degrees

j. INDEXING PLATE--_____ with circular hole patterns used to get set workpiece rotation to a specific _____ _____

LAP ASSIGNMENT SHEET #2

13. List the operations performed on dividing or indexing head. (Hint: There are four cutting operations, two machining operations, and two other types.)

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

g. _____

h. _____

14. List reasons for using cutting fluids.

a. _____

b. _____

c. _____

d. _____

15. List basic groups of cutting fluids.

a. _____

b. _____

c. _____

d. _____

16. Fill in the blanks to complete statements concerning coolant application methods and descriptions.

a. MIST SYSTEM--_____ (10 to 80 psi) applies to cutter and workpiece mist of _____ or _____ fluid mixed with air

b. COLD AIR--Pressurized _____ _____ is directed over tool and workpiece

c. PASTE OR SOLID APPLICATION--Coolant is applied to tool and workpiece manually by _____ or _____ _____

d. _____ _____--Coolant under low pressure from one or more nozzles floods tool and workpiece; most common method of applying fluids

17. Answer the following questions about advantages and disadvantages of methods for applying coolant.

a. Which methods are easy to install? _____

_____

b. Which method obscures visibility of cut? _____

c. Which methods are expensive to use? _____

_____

d. Which method is inexpensive? _____

_____

e. Which method is costly to install and messy? _____

_____

f. Which method offers good lubrication, good visibility of cut, and excellent coolant distribution? _____

18. Match cutter failure and finish problem to their possible causes. Write the correct numbers in the blanks. Numbers will be used more than once and blanks may contain more than one answer.

_____a.	Cutter slipping	1.	Chatter
_____b.	Outboard arbor bushing loose	2.	Cutter dulling rapidly
_____c.	Incorrect machine operation	3.	Cutting edge chipping
_____d.	Workpiece not properly supported	4.	Cutter breaking
_____e.	Incorrect coolant	5.	Workpiece material hardening
_____f.	Coolant flow direction wrong	6.	Cutting edge clogging
_____g.	Cutter not properly positioned	7.	Cutting edge overheating
_____h.	Dull cutter	8.	Excessive cratering of carbide
_____i.	Not enough cutting edges		
_____j.	Excessive revolutions per minute (rpm)		
_____k.	Inadequate coolant at cut		
_____l.	Chatter		
_____m.	Low revolutions per minute (rpm)		
_____n.	Excessive feed		
_____o.	Incorrect feed (high or low)		
_____p.	Loose gibs or play in table		
_____q.	Bent arbor		
_____r.	Workpiece not held rigidly		
_____s.	Cutter ground improperly		
_____t.	Incorrect cutter		
_____u.	Cut too deep		
_____v.	Too many teeth or flutes in cutter		
_____w.	Chips being recut		

19. Stop. Have your instructor evaluate your LAP assignment sheet. If your instructor is satisfied with your progress, continue to Learning Step 7. If additional study is required, discuss a study program with your instructor. Once you have completed that program to your instructor's satisfaction, continue to Learning Step 7.

MILLING MACHINES
UNIT 1--INTRODUCTION TO MILLING MACHINES

LAP ASSIGNMENT SHEET #3

NAME _____ SCORE _____

1. State the rules for milling machine safety.

   a. Rags--_____

   _____

   _____

   b. Setup--_____

   _____

   _____

   c. Cutting tools-- _____

   _____

   _____

   d. Feed-- _____

   _____

   _____

   e. Cutter rotation-- _____

   _____

   _____

   f. Measurements or adjustments-- _____

   _____

   _____

   g. Conventional or up-milling-- _____

   _____

   _____

h. Changing parts-- _____

_____

_____

i. Arbor nut and drawbar-- _____

_____

_____

j. Revolving cutter-- _____

_____

_____

k. Machine controls-- _____

_____

_____

l. Running machine-- _____

_____

_____

m. Travel levers-- _____

_____

_____

n. Positioning workpiece-- _____

_____

_____

o. Standing by machine-- _____

_____

_____

p. Warning tags or signs-- _____

_____

_____

q. Chips-- _____

_____

_____

r. Compressed air-- _____

_____

_____

s. Work area-- _____

_____

_____

t. Heavy objects-- _____

_____

_____

u. Guards-- _____

_____

_____

v. Clothing-- _____

_____

_____

w. Safety glasses with side shields-- _____

_____

_____

LAP ASSIGNMENT SHEET #3

2. Stop. Have your instructor evaluate your LAP assignment sheet. If your instructor is satisfied with your progress, continue to Learning Step 11. If additional study is required, discuss a study program with your instructor. Once you have completed that program to your instructor's satisfaction, continue to Learning Step 11.

MILLING MACHINES
UNIT I--INTRODUCTION TO MILLING MACHINES

LAP ASSIGNMENT SHEET #4

NAME _____ SCORE _____

1. Calculate the simple and direct indexing required in each operation described below. For direct indexing, assume that you are using a 24-hole plate. To calculate simple indexing, assume that you are using a 40:1 ratio dividing head and a three-plate indexing set with the following hole patterns:

Plate 1 -- 15-16-17-18-19-20

Plate 2 -- 21-23-27-28-29-31

Plate 3 -- 35-37-39-41-43-45

Show all of your work.

a. Calculate the indexing required to mill a gear with 12 teeth.

Simple: _____ turn(s) _____ hole(s) in _____-hole pattern

Direct: _____ holes

b. Calculate the simple indexing to mill a spline having 32 divisions.

Simple: _____ turn(s) _____ hole(s) _____-hole pattern

LAP ASSIGNMENT SHEET #4

c. Calculate the simple indexing to mill a spline having 84 divisions.

Simple: _____ turn(s) _____ hole(s) in _____-hole pattern

d. Calculate the simple indexing for a gear having 15 teeth.

Simple: _____ turn(s) _____ hole(s) in _____-hole pattern

e. Calculate the simple indexing required to a mill a gear having 48 teeth.

Simple: _____ turn(s) _____ hole(s) in _____-hole pattern

f. Calculate the direct indexing for drilling 3 holes on the circumference of a pipe.

Direct: _____ holes

g. Calculate the direct indexing for drilling 4 holes on the circumference of a pipe.

Direct: _____ holes

2. Stop. Have your instructor evaluate your LAP assignment sheet. If your instructor is satisfied with your progress, continue to Learning Step 15. If additional study is required, discuss a study program with your instructor. Once you have completed that program to your instructor's satisfaction, continue to Learning Step 15.

MILLING MACHINES
UNIT I--INTRODUCTION TO MILLING MACHINES

LAP ASSIGNMENT SHEET #5

NAME _____ SCORE _____

1. List the information you must have before you can calculate cutting speed.

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

2. In the space below, state the formula for calculating spindle speed.

3. In the space below, state the formula for calculating feed.

4. Use the speed and feed charts following Assignment Sheet #3 (pages MM-91 through MM-101) to calculate machine speed and feed rates. Calculate the rough cut speed and feed rates only. Show your work.

   a. What are the speed and feed rates when using a 1/2-inch diameter four-flute end mill (HSS) to mill a slot 0.200 of an inch deep and 8.5 inches long in a medium carbon steel disc (1055)?

      Speed: _____ rpm Feed: _____ ipm

b. Drill a 3/4-inch diameter hole in a stainless steel plate (300 series) 1 inch thick.

Speed: _____ rpm Feed: _____ ipm

c. Cut a 1/2-inch slot 1/4 inch deep in an aluminum alloy bar with a four-flute, 1/2-inch end mill of high-speed steel.

Speed: _____ rpm Feed: _____ ipm

d. Cut a slot 0.150 inch deep in a steel bar (SAE 1055) using a two-flute, 3/4-inch diameter end mill (HSS).

Speed: _____ rpm Feed: _____ ipm

5. Stop. Have your instructor evaluate your LAP assignment sheet. If your instructor is satisfied with your progress, continue to Learning Step 19. If additional study is required, discuss a study program with your instructor. Once you have completed that program to your instructor's satisfaction, continue to Learning Step 19.

MILLING MACHINES
UNIT I--INTRODUCTION TO MILLING MACHINES

ANSWERS TO PRETEST

1.

a.	5	f.	7	k.	14
b.	8	g.	2	l.	12
c.	4	h.	6	m.	9
d.	1	i.	11	n.	15
e.	3	j.	10	o.	13

2. Answer should include any five of the following

a.	Horizontal mill	e.	Bed-type manufacturing mill
b.	Turret mill	f.	Precision jig bore
c.	Vertical mill	g.	Computerized mill
d.	Tracer or duplicating mill		

3.

a.	14	f.	6	k.	2
b.	3	g.	1	l.	9
c.	10	h.	4	m.	13
d.	7	i.	8	n.	11
e.	12	j.	5		

4. COLUMN

a.	9	d.	1	g.	4
b.	3	e.	6	h.	8
c.	5	f.	7	i.	2

KNEE

a.	3	d.	4	g.	8
b.	2	e.	5	h.	6
c.	1	f.	9	i.	7

ANSWERS TO PRETEST

SADDLE

a. 1
b. 4
c. 3
d. 2

TABLE

a. 3
b. 1
c. 4
d. 5
e. 2

5.

a. 10	f. 9	k. 8
b. 11	g. 3	l. 5
c. 4	h. 7	m. 14
d. 1	i. 13	n. 6
e. 2	j. 12	

6. MILLING HEAD

a. 12	f. 10	k. 4
b. 11	g. 8	l. 15
c. 7	h. 3	m. 2
d. 9	i. 5	n. 1
e. 14	j. 13	o. 6

RAM AND SWIVEL

a. 3	d. 4	g. 7
b. 6	e. 5	h. 8
c. 1	f. 2	

ANSWERS TO PRETEST

TABLE

a. 1
b. 3
c. 2
d. 5
e. 4

SADDLE AND KNEE

a. 3
b. 2
c. 5
d. 4
e. 1
f. 6

7. a. V-block and clamp
   b. Air vise
   c. Fixture
   d. Hold-down clamp
   e. Rotary table
   f. Precision angle table (adjustable)
   g. Heavy-duty angle vise
   h. Vise with swivel base
   i. Indexing (dividing) head and attachments
   j. Angle plate

8. a. Single-end, two-flute helical end mill
   b. Woodruff keyseat cutter
   c. Combination drill and countersink (center drill)
   d. Roughing end mill
   e. Reamer
   f. Double-end, two-flute helical end mill
   g. Four-flute end mill
   h. Straight-shank drill
   i. Plain metal-slitting saw
   j. Double-angle mill cutter
   k. Side mill cutter

ANSWERS TO PRETEST

l. Convex mill cutter

m. Single-angle mill cutter

n. Plain mill cutter

o. Counterbore with pilot

p. Helical mill cutter

q. Shell mill cutter

r. Corner-rounding end mill (radius-cutting end mill)

s. Dovetail-cutting end mill

t. Insert-type end mill

u. Staggered-tooth mill cutter

v. Involute gear cutter

w. Ball-nose end mill

x. Countersink

y. Concave mill cutter

z. Corner-rounding mill cutter (radius cutter)

9. a. Style C arbor
   b. Shell mill arbor
   c. End mill holder
   d. Taper adapter
   e. Style B arbor
   f. Style A arbor
   g. Collet

10. a. 3
    b. 5
    c. 2
    d. 4
    e. 1
    f. 6

11. a. Use when handling cutters to avoid injury to hands; however, do not use around revolving cutters

    b. Make sure that setup holds workpiece rigidly and that workpiece is tightly clamped to prevent slippage under cutter force, which may result in damage to cutter or workpiece or in injury to personnel

ANSWERS TO PRETEST

c. Make sure that cutting tools are always keyed to arbor or held securely in holder to prevent slippage

d. Adjust so that workpiece moves at proper feed to prevent damage to cutter and to produce desired finish

e. Adjust so that cutter rotates at proper surface feet per minute to prevent damage to cutter

f. To eliminate the possibility of an accident, stop cutter rotation before taking measurements or making adjustments

g. Feed work into cutter or against rotation of cutter when making heavy cuts

h. To avoid possible injury to hands or arms, move workpiece as far away from cutter as possible

i. Never attempt to tighten or loosen arbor nut or drawbar with machine power

j. Never reach over or touch revolving cutter with hands

k. Know location and use of all machine controls

l. Always stay within reach of stop switch while machine is running; never leave a running machine unattended

m. Always check machine travel levers before using machine

n. Always use handcranks when positioning workpiece near cutter; never use power to set up

o. Never lean on machine

p. Never use a machine that has a sign or warning tag indicating a dangerous condition or indicating that machine needs repair

q. Never handle chips with bare hands because they can cut or burn

r. Take extreme caution to avoid forcing chips between work surfaces and to prevent injury from flying chips

s. To prevent the possibility of slipping or stumbling, keep area around machine clean and free of oil, chips, and other obstructions

t. Use a hoist or ask for help when lifting

u. Never operate a machine with guards removed

v. Wear close-fitting clothing, with shirt tucked in and sleeves buttoned or rolled above elbows

w. Wear at all times

12. a. Indexing crank
b. Sector arm lockscrew
c. Indexing plate
d. Indexing plate stop
e. Spindle nose
f. Spindle lock
g. Direct-indexing plunger and pin
h. Direct-indexing holes
i. Sector arms
j. Indexing crank plunger pin

13. a. 5
b. 7
c. 2
d. 10
e. 6
f. 1
g. 8
h. 3
i. 9
j. 4

14. Answer should include any six of the following

a. Cutting splines
b. Cutting gears
c. Cutting helixes
d. Cutting cams
e. Machining straight-tooth clutches
f. Machining flats at designated angles
g. Drilling holes at designated angles
h. Ruling or graduating parts

15. a. 4 holes
b. 6 turn(s) 12 hole(s) in 18 - hole pattern
c. 0 turn(s) 16 hole(s) in 30 - hole pattern

16. Answer should include any three of the following

a. To keep workpiece and tool cool
b. To reduce friction by lubrication

c. To help prevent chips from welding to cutter

d. To wash chips away from workpiece and cutter

17. a. Cutting oils

b. Emulsifiable oils

c. Chemical and synthetic emulsions

d. Special cutting fluids

18. a. 1 c. 4

b. 2 d. 3

19. a. Mist system c. Flood cooling

b. Cold air d. Paste or solid application

20. CHATTER (Answer should include any five of the following)

a. Workpiece not held rigidly

b. Workpiece not properly supported

c. Dull cutter

d. Excessive feed

e. Excessive revolutions per minute (rpm)

f. Cutter not properly positioned

g. Cutter slipping

CUTTER DULLING RAPIDLY (Answer should include any five of the following)

a. Excessive revolutions per minute (rpm)

b. Inadequate coolant at cut

c. Incorrect coolant

d. Chatter

e. Incorrect feed (high or low)

f. Too many teeth or flutes in cutter

g. Cutter ground improperly

h. Incorrect cutter

CUTTING EDGE OVERHEATING (Answer should include any five of the following)

a. Excessive revolutions per minute (rpm)

b. Inadequate coolant at cut

c. Incorrect coolant

d. Incorrect cutter

e. Dull cutter

f. Cutter ground improperly

g. Cut too deep

CUTTING EDGE CLOGGING (Answer should include any five of the following)

a. Too many teeth or flutes in cutter

b. Excessive revolutions per minute (rpm)

c. Excessive feed

d. Incorrect cutter

e. Inadequate coolant at cut

f. Incorrect coolant

g. Coolant flow direction wrong

WORKPIECE MATERIAL HARDENING (Answer should include any three of the following)

a. Excessive revolutions per minute (rpm)

b. Excessive feed

c. Inadequate coolant at cut

d. Incorrect coolant

e. Dull cutter

ANSWERS TO PRETEST

CUTTING EDGE CHIPPING (Answer should include any eight of the following)

a. Low revolutions per minute (rpm)

b. Chatter

c. Excessive feed

d. Not enough cutting edges

e. Cut too deep

f. Cutter ground improperly

g. Loose gibs or play in table

h. Chips being recut

i. Cutter slipping

j. Bent arbor

k. Outboard arbor bushing loose

CUTTER BREAKING (Answer should include any five of the following)

a. Excessive feed

b. Cut too deep

c. Workpiece not held rigidly

d. Incorrect machine operation

e. Dull cutter

f. Loose gibs or play in table

g. Cutter slipping

EXCESSIVE CRATERING OF CARBIDE (Answer should include any three of the following)

a. Incorrect cutter

b. Excessive revolutions per minute (rpm)

c. Excessive feed

d. Cutter ground improperly

ANSWERS TO PRETEST

21. a. Speed: 640 rpm Feed: 4.48 ipm

b. Speed: 90 rpm Feed: 6.48 ipm

MILLING MACHINES
UNIT I--INTRODUCTION TO MILLING MACHINES

ANSWERS TO LAP ASSIGNMENT SHEET #1

1. a. 3
   b. 15
   c. 10
   d. 9
   e. 13
   f. 14
   g. 5
   h. 11
   i. 6
   j. 8
   k. 7
   l. 2
   m. 12
   n. 1
   o. 4

2. a. Turret mill
   b. Horizontal mill
   c. Computerized mill
   d. Bed-type manufacturing mill
   e. Tracer or duplicating mill
   f. Vertical mill
   g. Precision jig borer

3. a. Spindle reversing lever
   b. High/neutral/low selector lever
   c. Column
   d. Overarm
   e. Spindle
   f. Start/stop switches
   g. Overarm support
   h. Table
   i. Saddle
   j. Knee
   k. Elevating screw housing
   l. Base
   m. Knee motor drive
   n. Spindle motor cover

ANSWERS TO LAP ASSIGNMENT SHEET #1

4. KNEE

a.	7	f.	2
b.	4	g.	1
c.	5	h.	9
d.	3	i.	6
e.	8		

TABLE

a.	1	d.	2
b.	5	e.	4
c.	3		

COLUMN

a.	2	f.	6
b.	1	g.	8
c.	9	h.	4
d.	7	i.	3
e.	5		

SADDLE

a.	2	c.	4
b.	3	d.	1

5.

a.	Motor	h.	Knee
b.	Milling head	i.	Saddle
c.	High/neutral/low selector lever	j.	Table
d.	Ram	k.	Spindle
e.	Column	l.	Spindle power feed
f.	Base	m.	Speed indicator
g.	Elevating screw housing	n.	Drawbar

ANSWERS TO LAP ASSIGNMENT SHEET #1

6. MILLING HEAD

a.	15	i.	3
b.	13	j.	14
c.	6	k.	4
d.	11	l.	10
e.	12	m.	2
f.	1	n.	8
g.	7	o.	5
h.	9		

SADDLE AND KNEE

a.	1	d.	5
b.	2	e.	3
c.	6	f.	4

TABLE

a.	4	d.	1
b.	2	e.	3
c.	5		

RAM AND SWIVEL

a.	3	e.	2
b.	7	f.	8
c.	5	g.	4
d.	6	h.	1

ANSWERS TO LAP ASSIGNMENT SHEET #1

7. a. Vise with swivel base
   b. Air vise
   c. Angle plate
   d. Hold-down clamp
   e. V-block and clamp
   f. Precision angle table (adjustable)
   g. Fixture
   h. Heavy-duty angle vise
   i. Rotary table
   j. Indexing (dividing) head and attachments

8. a. Roughing end mill
   b. Woodruff keyseat cutter
   c. Single-end, two-flute helical end mill
   d. Combination drill and countersink (center drill)
   e. Reamer
   f. Ball-nose end mill
   g. Corner-rounding mill cutter (radius cutter)
   h. Involute gear cutter
   i. Concave mill cutter
   j. Staggered-tooth mill cutter
   k. Countersink
   l. Insert-type end mill
   m. Corner-rounding end mill (radius-cutting end mill)
   n. Helical mill cutter
   o. Counterbore with pilot
   p. Dovetail-cutting end mill
   q. Shell mill cutter
   r. Plain metal-slitting saw
   s. Side mill cutter
   t. Plain mill cutter

u. Double-angle mill cutter

v. Single-angle mill cutter

w. Convex mill cutter

x. Double-end, two-flute helical end mill

y. Four-flute end mill

z. Straight-shank drill

9. a. Style B arbor
   b. Collet
   c. Shell mill arbor
   d. Style C arbor
   e. Taper adapter
   f. Style A arbor
   g. End mill holder

10. a. 3
    b. 6
    c. 5
    d. 1
    e. 4
    f. 2

11. a. Indexing crank
    b. Sector arm lockscrew
    c. Indexing plate
    d. Indexing plate stop
    e. Spindle nose
    f. Spindle lock
    g. Direct-indexing plunger and pin
    h. Direct-indexing holes
    i. Sector arms
    j. Indexing crank plunger pin

12. CUTTING

    a. Splines
    b. Helixes
    c. Gears
    d. Cams

    MACHINING

    a. Straight-tooth clutches
    b. Flats at designated angles

ANSWERS TO LAP ASSIGNMENT SHEET #1

DRILLING--Holes at designated angles

RULING OR GRADUATING--Parts

13. a. Cool
    b. Friction
    c. Welding
    d. Wash

14. a. 4
    b. 1
    c. 3
    d. 2

15. a. Paste or solid application
    b. Flood cooling
    c. Cold air
    d. Mist system

16. FLOOD COOLING

    a. Advantages (Answer should include the following)

        1) Excellent lubrication and cooling

        2) Good chip removal

    b. Disadvantages (Answer should include any two of the following)

        1) Expensive to use

        2) Messy

        3) Costly to install

        4) Obsures visibility of cut

    MIST SYSTEM

    a. Advantages (Answer should include any two of the following)

        1) Good lubrication

        2) Good visibility of cut

        3) Excellent coolant distribution

        4) Easy to install

b. Disadvantages (Answer should include any two of the following)

1) Limited cooling power

2) Must be used in a well-ventilated area

3) Subject to clogging

4) Requires air source and filter system

PASTE OR SOLID APPLICATION

a. Advantages (Answer should include any two of the following)

1) Excellent for hand operations

2) No additional equipment required

3) Inexpensive

b. Disadvantages (Answer should include any two of the following)

1) Dangerous when using power equipment

2) Poor cooling power

3) Poor chip control

COLD AIR

a. Advantages (Answer should include any two of the following)

1) Good visibility of cut

2) Easy to install

3) Good chip control

b. Disadvantages (Answer should include the following)

1) No lubrication

2) Expensive

17. CHATTER

a, c, d, f, g, h, j

ANSWERS TO LAP ASSIGNMENT SHEET #1

CUTTING EDGE OVERHEATING

a, b, c, f, g, j, l

CUTTER BREAKING

a, c, d, e, g, i, j

CUTTER DULLING RAPIDLY

a, b, d, e, h, j, k, l

EXCESSIVE CRATERING OF CARBIDE

a, c, d, f

CUTTING EDGE CHIPPING

a, d, e, f, g, h, k, l, m, o, p

CUTTING EDGE CLOGGING

b, c, e, f, g, j, k

WORKPIECE MATERIAL HARDENING

a, c, d, f, h

MILLING MACHINES
UNIT I--INTRODUCTION TO MILLING MACHINES

ANSWERS TO LAP ASSIGNMENT SHEET #2

1. a. Circumference, spaces
   b. Spindles
   c. Work-holding, longitudinally
   d. Circular, cutter
   e. Revolving cutter
   f. Lubricant
   g. Table, traversely
   h. Stops, power-feed
   i. Right, left
   j. Lateral, crosswise
   k. Up, down
   l. Lost motion, direction, feed
   m. Steel bolt
   n. Selectors
   o. Transmit power

2. a. Horizontal mill
   b. Turret mill
   c. Vertical mill
   d. Tracer or duplicating mill
   e. Bed-type manufacturing mill
   f. Precision jig bore
   g. Computerized mill

3. a. Spindle reversing lever
   b. High/neutral/low selector lever
   c. Column
   d. Overarm
   e. Spindle
   f. Start/stop switches
   g. Overarm support
   h. Table
   i. Saddle
   j. Knee
   k. Elevating screw housing
   l. Base
   m. Knee motor drive
   n. Spindle motor cover

ANSWERS TO LAP ASSIGNMENT SHEET #2

4. COLUMN

a. Column, coolant
b. Spindle motor
c. Ram-type
d. Arbors
e. Rotation
f. Guide, support
g. Speed
h. Column
i. Revolutions per minute (rpm)

KNEE

a. Knee assembly
b. Overrides, feed
c. Cross-feed, elevating
d. Manual traverse
e. Column
f. Rate
g. Knee, elevating screw
h. Up, down
i. Power movement

SADDLE

a. Lock
b. Knee
c. Slide, dovetails
d. Power feed

TABLE

a. Maximum movement
b. Work-holding
c. Table movement
d. Table
e. Slots, stop, table engaging

5. a. Motor
b. Milling head
c. High/neutral/low selector lever
d. Ram
e. Column
f. Base
g. Elevating screw housing
h. Knee
i. Saddle
j. Table
k. Spindle
l. Spindle power feed
m. Speed indicator
n. Drawbar

ANSWERS TO LAP ASSIGNMENT SHEET #2

6. MILLING HEAD

a. Spindle
b. Spindle, bearing
c. Quill
d. Spindle
e. Movement
f. Manual
g. Cutter holder
h. Feed control
i. Spindle
j. Rate
k. Quill
l. Quill
m. Drawbar
n. Up, down
o. Starts, stops

RAM AND SWIVEL

a. Right, left
b. Secures
c. Column, column
d. Back, forth
e. Rotated
f. Ram axis
g. Position
h. Perpendicular

TABLE

a. Indicates, selects
b. Longitudinally
c. Movement
d. Engages
e. Table movement

SADDLE AND KNEE

a. Up, down
b. Column
c. Saddle
d. Cross-feed, elevating
e. Saddle
f. Knee

ANSWERS TO LAP ASSIGNMENT SHEET #2

7. a. Hold-down clamp
   b. Fixture
   c. Precision angle table (adjustable)
   d. Rotary table
   e. Vise with swivel base
   f. Heavy-duty angle vise
   g. Angle plate
   h. Indexing (dividing) head and attachments
   i. Air vise
   j. V-block and clamp

8. a. Counterbore with pilot
   b. Corner-rounding end mill (radius-cutting end mill)
   c. Dovetail-cutting end mill
   d. Helical mill cutter
   e. Shell mill cutter
   f. Corner-rounding mill cutter (radius cutter)
   g. Countersink
   h. Insert-type end mill
   i. Ball-nose end mill
   j Involute gear cutter
   k. Concave mill cutter
   l. Reamer
   m. Combination drill and countersink (center drill)
   n. Roughing end mill
   o. Single-end, two-flute helical end mill
   p. Woodruff keyseat cutter
   q. Convex mill cutter
   r. Single-angle mill cutter
   s. Plain mill cutter
   t. Plain metal-slitting saw
   u. Double-angle mill cutter
   v. Side mill cutter
   w. Staggered-tooth mill cutter
   x. Four-flute end mill
   y. Double-end, two-flute helical end mill
   z. Straight-shank drill

9. a. Shell mill arbor
   b. Collet
   c. Style C arbor
   d. End mill holder
   e. Taper adapter
   f. Style A arbor
   g. Style B arbor

ANSWERS TO LAP ASSIGNMENT SHEET #2

10. a. Digital readout
    b. Horizontal attachment for vertical mill
    c. Dividing or indexing head
    d. Boring head
    e. Slotting head
    f. Vertical head for horizontal mill

11. a. Indexing crank
    b. Sector arm lockscrew
    c. Indexing plate
    d. Indexing plate stop
    e. Spindle nose
    f. Spindle lock
    g. Direct-indexing plunger and pin
    h. Direct-indexing holes
    i. Sector arms
    j. Indexing crank plunger pin

12. a. Sector
    b. Gearing
    c. Nose
    d. Lock
    e. Simple, disengaged
    f. Exact movement
    g. Lock in
    h. Number
    i. Spindle nose, 15
    j. Disc, partial turn

13. a. Cutting splines
    b. Cutting gears
    c. Cutting helixes
    d. Cutting cams
    e. Machining straight-tooth clutches
    f. Machining flats at designated angles
    g. Drilling holes at designated angles
    h. Ruling or graduating parts

14. a. To keep workpiece and tool cool
    b. To reduce friction by lubrication
    c. To help prevent chips from welding to cutter
    d. To wash chips away from workpiece and cutter

ANSWERS TO LAP ASSIGNMENT SHEET #2

15. a. Cutting oils
    b. Emusifiable oils
    c. Chemical and synthetic emulsions
    d. Special cutting fluids

16. a. Jet, soluble, synthetic
    b. Cold air
    c. Brush, oil can
    d. Flood cooling

17. a. Mist system, cold air
    b. Flood cooling
    c. Flood cooling, cold air
    d. Paste or solid application
    e. Flood cooling
    f. Mist system

18. a. 1, 3, 4
    b. 3
    c. 4
    d. 1
    e. 2, 5, 6, 7
    f. 6
    g. 1
    h. 1, 4, 5, 7
    i. 3
    j. 1, 2, 5, 6, 7, 8
    k. 2, 5, 6, 7
    l. 2, 3
    m. 3
    n. 1, 3, 4, 5, 6, 8
    o. 2
    p. 3, 4
    q. 3
    r. 1, 4
    s. 2, 3, 7, 8
    t. 2, 6, 7, 8
    u. 3, 4, 7
    v. 2, 6
    w. 3

MILLING MACHINES
UNIT I--INTRODUCTION TO MILLING MACHINES

ANSWERS TO LAP ASSIGNMENT SHEET #3

1. a. Use when handling cutters to avoid injury to hands; however, do not use around revolving cutters

   b. Make sure that setup holds workpiece rigidly and that workpiece is tightly clamped to prevent slippage under cutter force, which may result in damage to cutter or workpiece or in injury to personnel

   c. Make sure that cutting tools are always keyed to arbor or held securely in holder to prevent slippage

   d. Adjust so that workpiece moves at proper feed to prevent damage to cutter and to produce desired finish

   e. Adjust so that cutter rotates at proper surface feet per minute to prevent damage to cutter

   f. To eliminate the possibility of an accident, stop cutter rotation before taking measurements or making adjustments

   g. Feed work into cutter or against rotation of cutter when making heavy cuts

   h. To avoid possible injury to hands or arms, move workpiece as far away from cutter as possible

   i. Never attempt to tighten or loosen arbor nut or drawbar with machine power

   j. Never reach over or touch revolving cutter with hands

   k. Know location and use of all machine controls

   l. Always stay within reach of stop switch while machine is running; never leave a running machine unattended

   m. Always check machine travel levers before using machine

   n. Always use handcranks when positioning workpiece near cutter; never use power to set up

   o. Never lean on machine

   p. Never use a machine that has a sign or warning tag indicating a dangerous condition or indicating that machine needs repair

   q. Never handle chips with bare hands because they can cut or burn

ANSWERS TO LAP ASSIGNMENT SHEET #3

r. Take extreme caution to avoid forcing chips between work surfaces and to prevent injury from flying chips

s. To prevent the possiblity of slipping or stumbling, keep area around machine clean and free of oil, chips, and other obstructions

t. Use a hoist or ask help when lifting

u. Never operate a machine with guards removed

v. Wear close-fitting clothing, with shirt tucked in and sleeves buttoned or rolled above elbows

w. Wear at all times

MILLING MACHINES
UNIT I--INTRODUCTION TO MILLING MACHINES

ANSWERS TO LAP ASSIGNMENT SHEET #4

1. a. Simple: 3 turn(s) 5 hole(s) 15 - hole pattern

   Direct: 2 holes

   b. Simple: 1 turn(s) 4 hole(s) in 16 - hole pattern

   c. Simple: 0 turn(s) 10 hole(s) in 21 - hole pattern

   d. Simple: 2 turn(s) 10 hole(s) in 15 - hole pattern

   e. Simple: 0 turn(s) 15 hole(s) in 18 - hole pattern

   f. Direct: 8 holes

   g. Direct: 6 holes

MILLING MACHINES
UNIT I--INTRODUCTION TO MILLING MACHINES

ANSWERS TO LAP ASSIGNMENT SHEET #5

1. a. Operation to be performed

   b. Material to be cut

   c. Type of cutting tool material to be used

   d. Depth of cut

   e. Appropriate cutting speed table for operation, materials, and depth of cut

2. $rpm = \frac{4 \times CS}{\text{Diameter of Cutter in Inches}}$

3. Feed = Feed Rate per Tooth x Number of Teeth x Spindle Speed

   = Ft x T x rpm

4. a. Speed: 600 rpm Feed: 2.4 ipm

   b. Speed: 640.00 rpm Feed: 8.960 ipm

   c. Speed: 2000 rpm Feed: 16 ipm

   d. Speed: 400 rpm Feed: 1.6 ipm